# THE SCIENCE TEACHER

VOLUME 27, NUMBER 2 • MARCH 1960

# THE SCIENCE TEACHER




*The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.*


**Journal of the National Science Teachers Association**

**Volume 27, Number 2 • March 1960**

# Editorial

Members of NSTA frequently write to tell us how much they appreciate the many services and materials that in their opinions "hit the bull's eye."

Many behind-the-scenes activities of NSTA also are striking some important targets. Being beyond the scope of direct services to members, however, it is somewhat of a problem to communicate fully the nature and significance of these endeavors. The "NSTA Activities" and "FSA Activities" pages of *TST* carry such reports in each issue. But there is so much going on I believe we can use this column to good advantage this month in brief descriptions of several current efforts and projects.

First, in the realm of facilities for the teaching of science, NSTA with the collaboration of two other agencies has held exploratory seminars on (a) implications for facilities of trends and new dimensions in science education, and (b) the role of kits, models, and scientific toys in learning about science.

How much science are boys and girls learning (and how good is it) through the materials now being made available by the multimillion dollar scientific toy-model-kit industry? What are the implications for classroom instruction in science? To what extent should our profession attempt to develop criteria and guidelines for selection and use, both by teachers in school and by parents outside of school? What changes in classroom and laboratory design and furnishings during the next decade are called for by current tendencies to accelerate the science program, and to provide seminars, research-type opportunities, and advanced courses for able students in grades 11-14? These are indicative of the questions considered in the seminars. Decisions on follow-up actions, if any, from the seminars are still pending.

Another important role of NSTA is that of cooperation with other professional societies. Three diverse examples can be cited.

1. NSTA has provided an official representative of high school physics teaching to meet with the advisory committee for a project on the design of physics buildings. The project is being carried on by the American Association of Physics Teachers.

2. NSTA has joined three scientific societies in the formation of the Metallurgy-Ceramics Foundation to deal with problems of education in these fields at both secondary and collegiate levels.

3. Within the NEA family, NSTA now has under way a joint project with the Department of Elementary School Principals. This will produce a booklet on science for parents of elementary-age youngsters. NSTA has joined with some 20 other NEA units also to form a Council on Instruction, an agency to study the over-arching problems that transcend subject matter and department boundaries. (The NSTA Executive Secretary is chairman of the group this year.)

Still another area which NSTA is exploring is a program in the field of international activities. Foreign visitors are constantly seeking data from us and the U. S. Office of Education on science programs in America. The forthcoming European tour by some 30 representatives of NSTA and science teachers of America may crystallize more fully our responsibilities in this field.

NSTA participation in these and other similar programs has been considered and approved, in line with policies of the Board of Directors. It is believed that these efforts can contribute significantly to the advancement of science education.

Magazines, packets, conventions, and projects as those mentioned above are among the services an organized profession can achieve. These are the projects in which NSTA participates through the support of 14,000 members—for their benefit and for the benefit of 50,000 other science teachers and their students.

Robert H. Carleton



THE SCIENCE TEACHER

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The membership year extends for one year from date of enrollment. Subscriptions are entered for either the calendar year or the school year.

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|---|---|
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* Includes the *Elementary School Science Bulletin* published monthly from September through April of each year.


Again congratulations to you and your staff for the excellence of the new dress, arrangement, and interesting contents of Volume 27, No. 1 (February issue) of *The Science Teacher*.

It isn't difficult to visualize the lift which any devoted teacher of science gets from seeing this professional journal, and the increasing confidence and enthusiasm in the job which results from the help which comes each month.

You're doing a great job for science!

PAUL E. KLOPSTEG, *Chairman*
*Board of Directors*
*American Association for the Advancement of Science*

Congratulations on the new and more functional format of *The Science Teacher*. I was intrigued—and pleased—with the explanation of the reasons for the change. I had always wondered why such changes are made. This one is a good one.

SISTER MARY MARTINETTE, B.V.M.
*Mundelein College*
*Chicago, Illinois*

I have been very pleased with my first year of a sustaining membership. *The Science Teacher* is looked forward to more than any other periodical, and the recently added *Science World*, which carries *Tomorrow's Scientists*, is eagerly read.

C. R. JONGEDYK
*3158 North Salina*
*Wichita, Kansas*

**EDITOR'S NOTE: The above letters are representative of the many which have been sent to us following the distribution of the February issue in its newly revised form. We confess to a pleasant glow of satisfaction in reading these letters, and we accept them on behalf of our Magazine Advisory Board, the contributors to TST, and the artist and production representative of our printer who works closely with our staff and guides us in producing our journal.**

**In addition to these letters, we welcome and invite your comments reporting critical analysis and positive suggestions for further improvement of future issues.**

Now that I have read the first issue of the 1960 volume of *The Science Teacher* with a new format, I thought I'd let you know how disappointed I am. The cut-up job of previous issues was bad enough but with all the reading matter cut up with advertisements, it is detestable. Of course, I know that ads and not subscriptions pay for the publication.

Maybe I have "missed the point," as one usually says, but referring to the article "First Aid or Safety First," it certainly did not show technique. On page 550-1 of the December 1959 issue of *The Science Teacher* I find safety and technique faults. On page 550, the student removing the beaker from the *tripod*, not ring stand, could have been using *beaker tongs* for safety. This is the positive approach. On page 551, the picture on the left agreed that careless filtering is taking place but not incomplete filtering necessarily, perhaps loss of filtrate, yes? On the right, maybe careful filtering is taking place, but the technique could have been proper. On the bottom of the page both pictures show how the tubing and especially the glass could penetrate the aprons if heat is too great. It may be exaggerated but the student could suffer stomach wounds. I think the article in question was poor in explaining safety. The two pictures on the top of page 551 add nothing to safety but do to poor techniques.

Incidentally, I still think that NSTA members should only vote for their own Regional Directors and not for those in other regions.

ANDREW A. SHEROCKMAN
*5231 Wolfe Drive*
*Pittsburgh, Pennsylvania*

**EDITOR'S NOTE: The article referred to above was included as a feature article to stimulate safety habits and was not intended to prescribe techniques. It was based, as indicated, on suggestions from the author and his experiences in the laboratory.**

# NEA NOTES

**EDITOR'S NOTE: From time to time, we will report events and data of interest from other NEA departments in this column. Additional information on the items reported may be obtained by writing the individual departments.**

**Legislation Division of NEA**

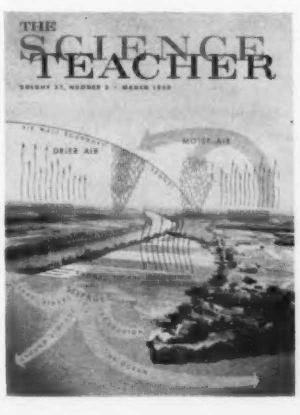
The House of Representatives is expected to begin debate this month on a moderate-sized school construction bill which friends of education hope to amend to include federal funds for teachers' salaries. The construction-only measure would authorize appropriations of $325 million for each of fiscal years 1961, 1962, and 1963. The Senate on February 4 passed by a vote of 51 to 34 a $1.8 billion bill which provides federal funds for school construction and teachers' salaries over a two-year period. This marked the first time in history that favorable Congressional action has been taken on legislation providing money for both salaries and construction.

**Department of Rural Education**

The Department of Rural Education will soon publish the book, *Children of Migratory Agricultural Workers*, by Elizabeth Sutton, Florida State University, based on three years of experience in a supervisory project in Palm Beach County, Florida, and North Hampton County, Virginia. The project was begun under the chairmanship of Howard A. Dawson, NEA Director of Rural Service.

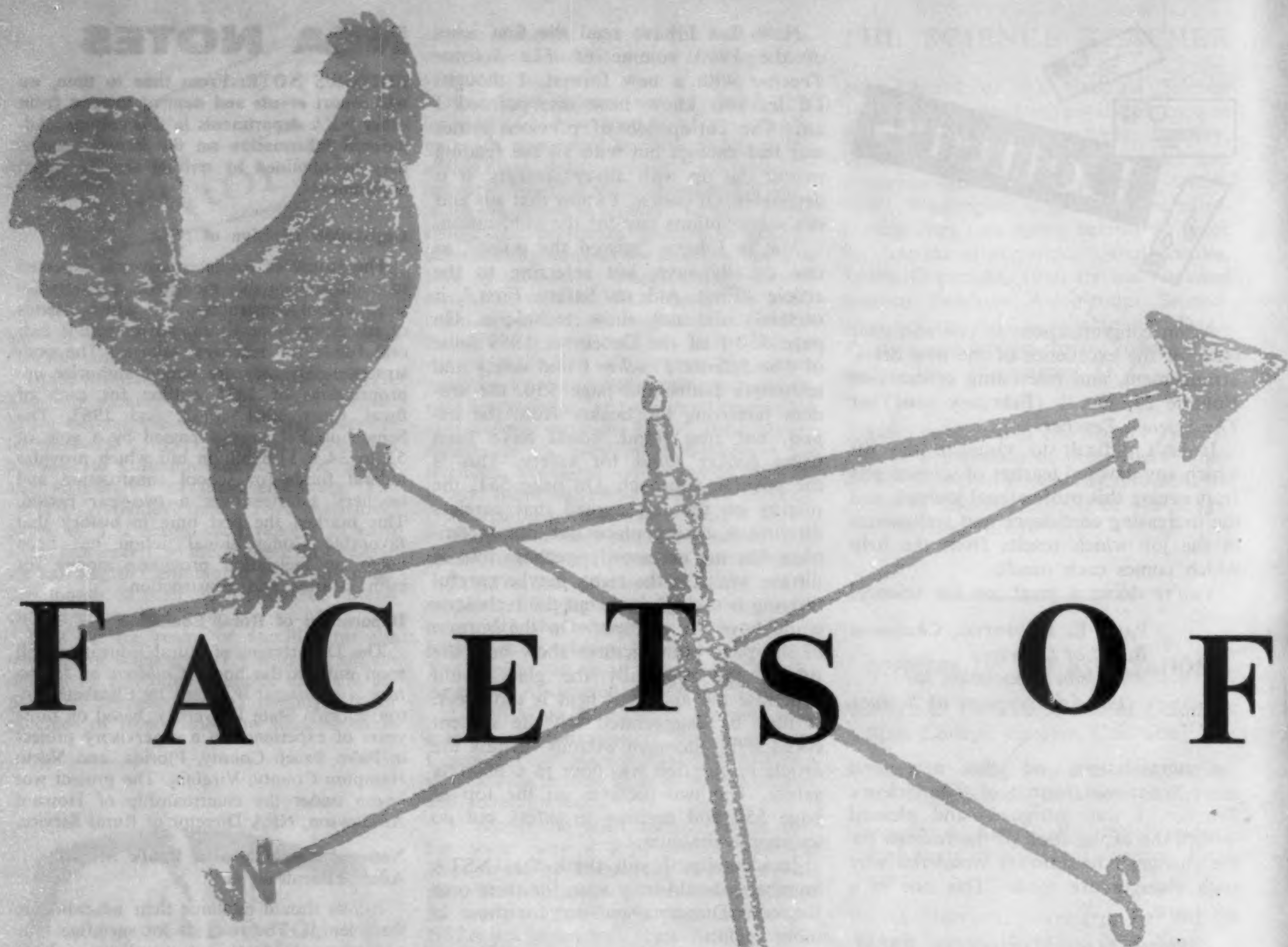
**National Association of Public School Adult Educators**

Adults should continue their education in the sciences. The rewards for spending time and energy to do this may well range from learning interesting information to finding a new career. To help adults to continue their education in science, the Association is planning a special curriculum publication tentatively entitled, "What Adults Can Learn in the Science Areas." The publication will be designed to aid public school adult educators develop science education programs suitable to the myriad interests and needs of adults.




## THIS MONTH'S COVER . . .

THE HYDROLOGIC CYCLE—The transport of moisture by evaporation from oceans and other bodies of water, soil, and vegetation into the atmosphere . . . to condense into clouds and precipitation, and thus return to the land and waters in a never-ending cycle.



# FACETS OF


**By H. E. LANDSBERG**

**Director, Office of Climatology, U. S. Weather Bureau, Washington, D.C.**


CLIMATE is part of our environment. It is an entity abstracted from the ever-changing weather. With topography and natural resources it is a basic element of our surroundings. Climate governs the flora and exercises a profound influence on the fauna. It rules the water supplies, determines our clothing, housing and, even to some extent, our health.

Long before the time of written history, man had been concerned with climate. His struggles with daily life and his migrations reflected the importance of this factor. Crude attempts at measurements antedate the present era. The Greek philosophers were well aware of the fact that climatic conditions had a relation to solar elevation above the horizon. That the inclination of the sun's rays with the horizontal influenced the temperature was well known to them. It gave rise to the name "climata" (or inclinations). The steeper an angle the sun's rays make with the surface of the earth, the higher are the temperatures. The greater their slant, the cooler it gets. Thus, the geographic latitude becomes a main cause for climatic differences.

We can demonstrate this very easily by observing the temperature of a flat surface on a calm, sunny day. This temperature follows the solar elevation above the horizon. We can also readily see that slopes to the south get warmer than slopes toward the north. Just as we can note the diurnal pattern, it is also easy to follow the annual course of temperature. This difference between summer and winter is again following the changing elevation of the sun. But here it becomes almost immediately obvious that other causes enter into shaping the march of temperature. The highest and lowest values do not any more coincide with the extremes of solar elevation. Instead they lag behind. This lag is a function of many factors but one of them is the influence of the oceans. At places far inland, the lag is short. At the coast or on islands it is long.

The distribution of land and sea on the earth exercises a very profound influence on the climate. The sun, by heating the earth near the equator more than at the poles, sets up the energy differences responsible for the general atmospheric circulation. But water masses and solid earth react differently to the heat transactions. Because of mobility a thicker layer of water gets involved than in the case of solid earth. In fact, the annual variation penetrates ten times deeper into the water than into the soil. This solid layer

# CLIMATE

heats quickly and cools quickly. The large water masses take longer to heat and act as a reservoir of heat in summer and as a sink in winter. In contrast, oceans furnish heat to the air in winter, but are relatively cool surfaces in summer. This again causes important regular variations in the general circulation. On an extended scale this is seen in the monsoons which blow from land to sea in winter and then from sea to land in the summer.

These large-scale phenomena can now be studied and, to some extent, be duplicated in the laboratory. If one heats the fluid in a slowly rotating dishpan with a heat source at the rim and cools it in the center, a circulation analogous to that in the earth's atmosphere is set up—easterly flow near the rim (= equator), westerly flow with eddies in the middle zone (= moderate latitudes), and easterlies again near the center (= pole). Dr. Dave Fultz of The University of Chicago has performed an excellent series of experiments showing

Cumulonimbus clouds as seen from the air.

U. S. WEATHER BUREAU, BUTLER

PHOTOS BY SOIL CONSERVATION SERVICE, U. S. DEPARTMENT OF AGRICULTURE

**Weather records are indispensable for studies of local and regional climate in areas dependent on agricultural activities.**

these effects. One can also duplicate the disturbances created in the flow of an obstacle (= mountain).

These experiments help us in a better understanding of the great variety of climates. In their world distribution these climates are an outgrowth of the general circulation. If the earth's surface were uniform and smooth, climatic conditions would be simple and readily predictable. The problems arise from the infinite mosaic of landscape and distribution of water surfaces. These often create notable climatic variations within a climatic zone. These small-scale patterns, often called microclimates, can be studied everywhere. They reflect such distinctions as the differences of night-time temperatures between a city and its suburbs, or a valley and a hill. On an even smaller scale one can note them within a garden, around a hedge, or between the north and south side of a house. Sometimes they are well reflected in the type of flowers that will grow or the dates on which they will start blooming.

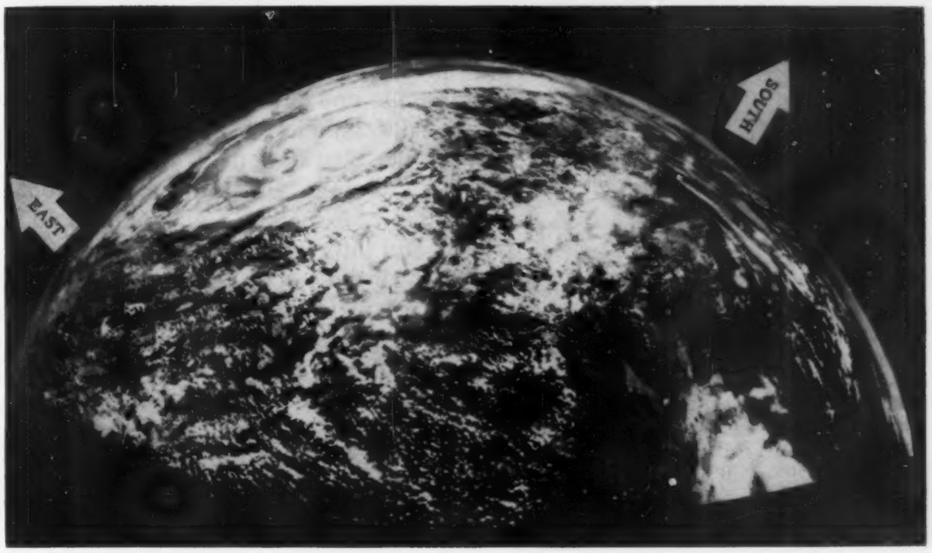
But climate is more than temperature. It includes the many elements which make up the day-to-day weather. Hence precipitation, atmospheric pressure, wind direction and speed, cloudiness, and special events such as thunderstorms are part of the climate. In weather studies and weather forecasting we treat these factors individually in a day-to-day fashion at many places simultaneously. In contrast, climatology deals with them as statistical collectives. The difference is analogous to research in medicine which deals primarily with the well-being of individuals and public health or insurance studies which deal with disease incidence in a large population. Just as the

**Typical thermometer shelter used at weather stations. Observer here performs a calibration of the radiosonde package which is sent aloft with a balloon to measure upper air conditions.**

U. S. WEATHER BUREAU

individual health problems influence the disease patterns of a community so do the multitude of weather events determine the climate.

For this reason all studies of climate start with individual observations of the various weather elements. Most of these observations can be made with simple instruments. Many of them, such as rain gauges and wind vanes, are easy "do-it-yourself" projects. The main requirement is steady attention to these elements each day of the year, for a considerable period if one wants to establish the climate of a place. Fortunately, it is a proud tradition in the United States to take these records. Interest in them has been lively since colonial days. No less a person than Thomas Jefferson kept a weather diary for decades. Today, volunteer cooperative observers of the U. S. Weather Bureau keep such records in about 12,000 communities. Their unheralded labors are the indispensable basis for studies of local and regional climate. The data from these climatic stations are most helpful for answering many practical questions. Among them are: What crops will profitably grow? How large a heating plant is needed for a building? Will there be enough rain to keep local water reservoirs adequately supplied for a growing community? Industry, when building a new plant, will consult climatic records to see if atmospheric conditions are conducive to accumlation of pollution products. Structural engineers want to know about maximum winds in an area to build safe towers and bridges. Most branches of engineering require background information of climatic conditions. This is particularly true if they are engaged in dam or road construction, layout of runways, transmission of power, radio propagation, or transportation. In commerce, marketing and advertising rely heavily on climatic information. As an example think of antifreeze: Supplies of it should be in the hands of distributors prior to the first freeze in autumn. As it takes weeks to transport this from the factories to all parts of the country the day-to-day




U. S. NAVY PHOTOGRAPH

Visible hurricane formation (Hazel), about 1000 miles in diameter, covers more than a million square miles. This is equal to about two-fifths of the area of the United States. The horizon extends almost 3000 miles from Oklahoma to Mexico. Photograph taken by Aerobee rocket over Texas and the Southwest. Fired from White Sands, New Mexico. (Upper left of earth photo shows hurricane spiral pattern.)

Lightning during Thunderstorm.

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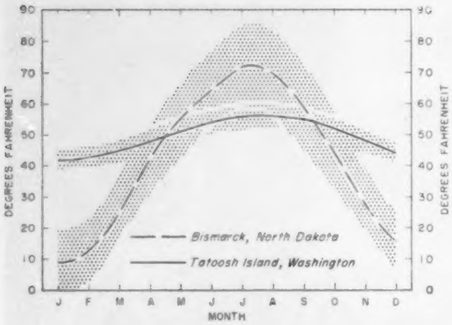



**FIGURE 1. Mean annual temperature curves for a location in a maritime climate (Tatoosh Island) and one in a continental climate (Bismarck). The shaded zone indicates the average daily temperature range. Note that both annual and daily swing are much larger in mid-continent than at the coast.**

forecasts of weather, which at best anticipate a five-day period, cannot help. Therefore, as best estimate the probable date, at a certain level of risk, is arrived at from the past record of this event. Similarly, for snow tires and chains the date of the first substantial snowfall can be estimated. In spring, the mean date of the last freeze is a good climatic guide for the planters of home gardens.

Compilation and analysis of the climatic data from 12,000 stations is a formidable task. Many of them have decades of daily observations, a few even as much as a century. Fortunately modern data processing systems have come to the aid of the climatologist. All current observations for over a decade and many of the earlier data have been placed on punched cards. Electronic machines permit the rapid calculation of means, standard deviations, and other statistical elements of the frequency distributions. Specialized problems in climatology have led to the use and development of new statistical techniques. Sometimes knowledge of the distribution of extreme values is important. Other times, the probability of exceeding a given threshold is useful information. In this connection, not all these statistics refer to the surface layer of the air. For the planning of jet air routes it is pertinent to know how often winds exceeded given values and from what directions they came in various layers high up in the atmosphere. Such data help in the compilation of wind-aid and -retard tables. The basic observations for these analyses come from free balloons tracked by radar to great heights.

The availability of the data in a form permitting their processing by machine has opened an enormous store of scientific information. Some intriguing new avenues of research will be detailed later. But even the punched card is not an unmixed blessing. It becomes bulky in quantity. At the National Weather Records Center in Asheville, North Carolina, which is the archives for all of the country's climatic data, 350 million cards have accumulated. The growth rate is well over 70,000 per day. These include many cards from upper air observations, from hourly readings at regular Weather Bureau offices, and from many foreign countries. New devices microfilm the cards and the film is used as a storage medium. It will eventually serve directly as an input medium into electronic computers, which will perform various statistical analyses.

**Dust Storm**

U. S. WEATHER BUREAU

In many of the applications of climatic data we use records in lieu of a long-range forecast. They serve usefully if we don't need to know when an event is going to take place. For example, it is immaterial to the operation of a heating plant in a building on what days of the year the temperature is going to be below zero, as long as we know that such days are going to happen, say, between five and ten times each year. We can then see to it that the heater has the capacity to handle the load. Similarly, if we construct a tower with a probable life expectancy of fifty years, we want to be sure that the probability is low to have wind speeds exceeding the strength of the structure within that period.

But as in any other physical science, we like to think about the possibilities of predicting future events. The oldest method in climatology has been to follow the lead of astronomy and search for cycles. Two such cycles are very prominent: One is 24 hours long, the other 365 days. These correspond to the axial rotation of the earth and the revolution around the sun. Not even these, however, show very precise repetitions in climatological data. Although there is a good chance to have the lowest temperature of the day about an hour before sunrise and the highest two hours after noon, there are many days on which these two events take place hours before or after these times. In the annual course of events, the coldest month of the year in the moderate latitudes of the Northern Hemisphere is usually January but a few times February, December, or even March may play that role. Similarly in summer, we can never be positive whether July or August will turn out to be warmer. In rainfall, some areas have pronounced dry and wet seasons but nowhere do these occur with clock-like precision.

Nonetheless the search for cyclical events has been carried on with determination by climatologists. It has been a very frustrating hunt. Perhaps we are —as it happens often in science— following the wrong trail. Yet one would expect some elements of regularity in a thermodynamic system operating within fixed geographic boundaries and dimensions. With long series of data on punched cards, new attempts

Average Date of Last 32° Temperature in Spring

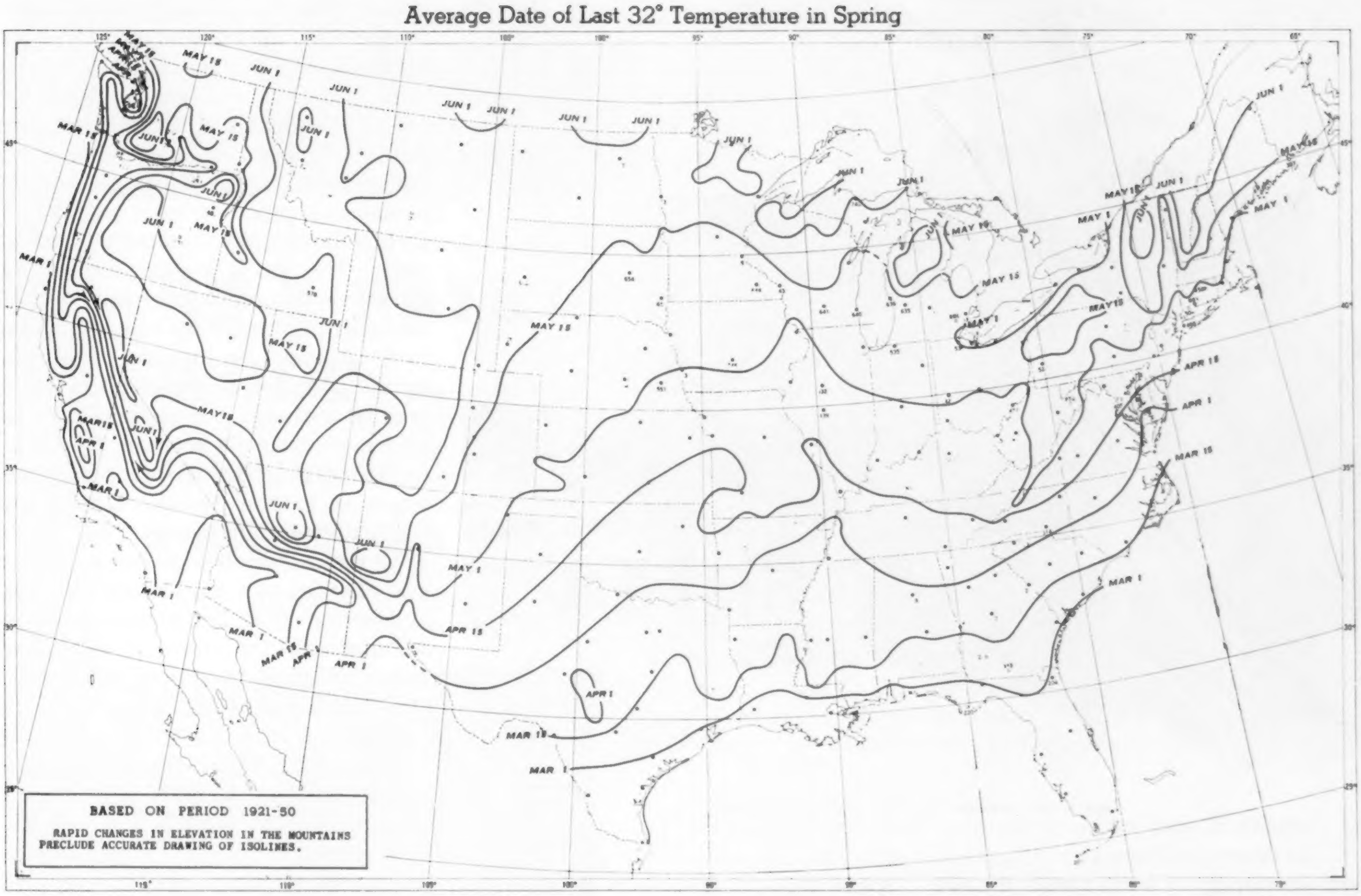
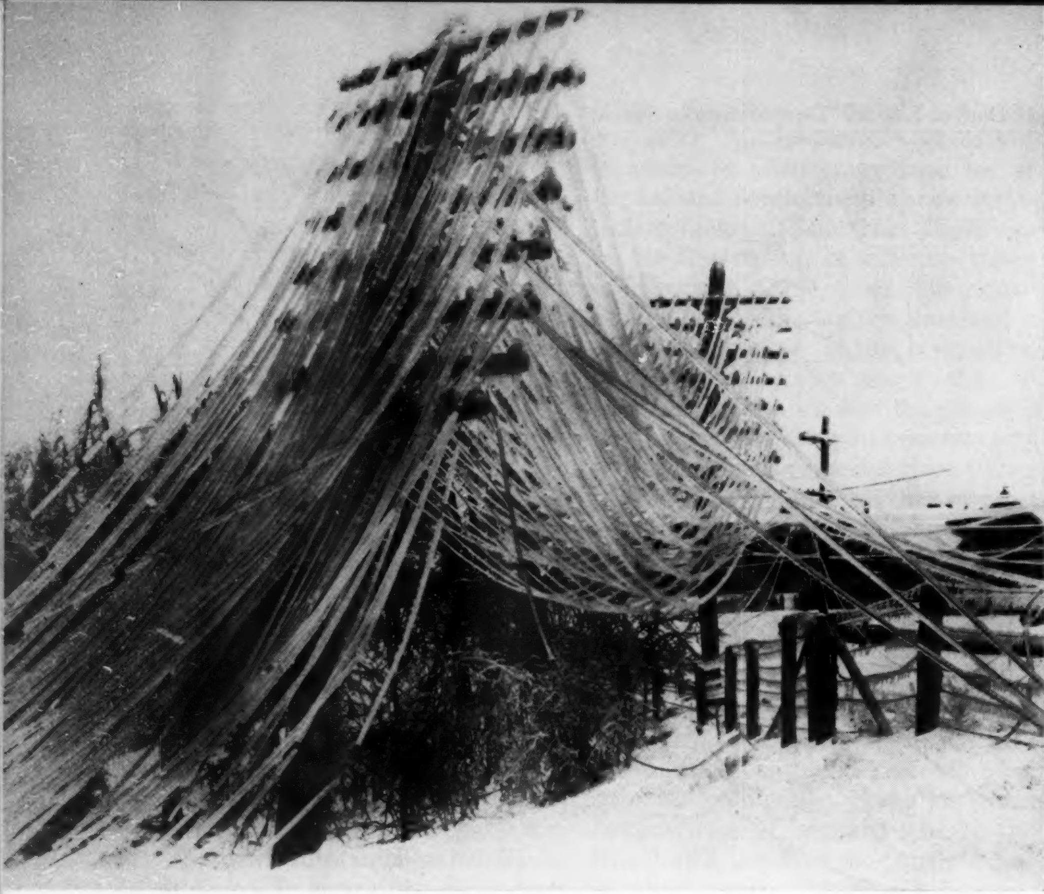



**FIGURE 2. Average date of last daily minimum temperature at 32° F in spring. This chart can serve as a planting guide.**

have been made to find hidden periodicities—hidden because they are certainly not immediately obvious. Powerful statistical methods that were originally developed in World War II to find sounds from submerged submarines in the welter of oceanic noise have found use in this problem. It is the procedure of power spectrum analysis, which is a form of generalized harmonic analysis. This indicates what general rhythms are contained in a time series of data. If we take some of our longer climatic records in our regions and subject them to this treatment a few facts emerge. One is that there is a slight tendency for repetitiousness in the interval from 5 to 7 days, and another around 12 to 20 days. These are not too pronounced but they seem to be real. The shorter period is probably connected with long waves in the westerly winds which dominate the moderate latitudes. These are probably somewhat analogous to standing waves of fluid dynamics in a closed system. Usually there are 3 to 5 such waves around the hemisphere. They are migrating around the earth so that each locality gets under the influence of one every few days. Occasionally, these waves show some precision and for a month or so we may have the experience that it will rain always on the same day of the week. Then the rhythm may disappear and another one take its place. How they change and why they change is still a puzzle. The longer cycle of around two weeks has something to do with the meridional exchange of energy between lower and higher latitudes. This too takes place in a pulsating form but the length of the rhythm is irregular and changes in the pulse rate are not yet within our predictive grasp.

If we look at longer time intervals about the same picture emerges from the analysis. In this area, much has been said and written about the climatic influence of varying solar conditions. These are often expressed in terms of sunspots. These manifestations of solar activity themselves are irregular. On an average the length of one cycle is 11 years but it can vary from 8 to 18 years. There is ample evidence for solar influences on terrestrial atmospheric events, especially in the ionosphere but as we come close to the surface the relations become very tenuous. The power spectrum analysis of data in the eastern United States shows a slight rhythm around 11 years. It accounts for less than 5 per cent of the over-all variability of temperature.

The closest connections to solar influences have always been noted in the tropics and for elements which integrate conditions over large areas. Among these are lake levels and river flows. If we arrange, for example, the river discharge of the Nile River according to sunspots over the period of eight cycles one can note that there is some variation within the cycle with a tendency for low discharges the year before sunspot minimum. Again less than 20 per cent of the variability is accounted for by the possible rhythmical contribution of the sunspot variation. With-



U. S. WEATHER BUREAU

Ice storm damage resembles ribboned shreds.

out knowledge of what causes the sunspots we can predict their changes only by statistical methods. Thus there is presently little chance of using this only partially predictable element to presage a terrestrial condition, which seems to follow these sunspots to a very limited degree. In spite of this lack of success the fascination of the problem remains.

We are equally puzzled by climatic fluctuations of still longer duration. These are measured in decades, centuries, and millenia. At one time climatologists deemed climate to be essentially invariant, at least over the span of a human life. The records we have accumulated definitely show that this is not so. There are slow secular trends. Over the past fifty years, for example, there has been a gradual warming over the globe. It is not uniform. In the Arctic it has been more pronounced than in moderate latitudes or in the southern hemisphere. In the eastern United States it is 1 or 2 degrees Fahrenheit. The winters, in particular, have become warmer. In the Arctic the warming has led to a gradual melting of the ice. Some scientists have even visualized a complete melting of the polar ice caps. Until we know what causes the warming process, this is only speculation. In fact, there is no assurance that the warming trend will continue. Of course, geological evidence shows that the whole earth has had a warmer climate for epochs counted in hundreds of millions of years. We also know that there have been ice ages. The last major glaciation showed a number of stages of advancing and retreating ice sheets. In North America, the latest continental glacier formation began to recede 11,000 years ago. So the question is: Are we now in an interglacial stage or are we slipping completely out of the ice age? Until the effects can be traced back to their causes, this question cannot be answered unequivocally. Some scientists believe that terrestrial phenomena are responsible for the large-scale climatic changes—possibly the formation of mountains and volcanic eruptions. Others think that astronomical conditions cause the changes—among them fluctuations in path elements of the earth's orbit, axial wobble, cosmic dust clouds between sun and earth, and possible changes in the output of solar energy and related phenomena.

For the latest fluctuations there are some arguments that man and his activities has had an influence. In the last century this was a claim made for deforestation and cultivation. No proof for large-scale changes can be given although local changes can be attributed to these activities. Over the last few decades, however, another element has entered. Through various man-made combustion processes large amounts of carbon dioxide have entered the atmosphere. This gas is a good absorber of infrared radiation. It intercepts part of the outgoing long-wave radiation from earth to space. An increase of this gas in the atmosphere would lead to a gradual warming. The period for which we have sufficiently accurate air analyses is too short to be sure of this increase in carbon dioxide. During the International Geophysical Year 1957-1958 the carbon dioxide concentration was checked at a world-wide network of stations. It is hoped that this will continue into the future so that close surveillance can be kept of this important constituent of the atmosphere.

Many sciences can point with pride to the solid doctrines that have been built. Questions have been answered and discoveries leading to better understanding have been made. In climatology, as in other phases of atmospheric science, many puzzles still remain. There are more questions than answers. These stay as a challenge to human imagination. Here is a vast domain still to be conquered and the scientists of tomorrow will find all the adventures of exploration waiting for them.

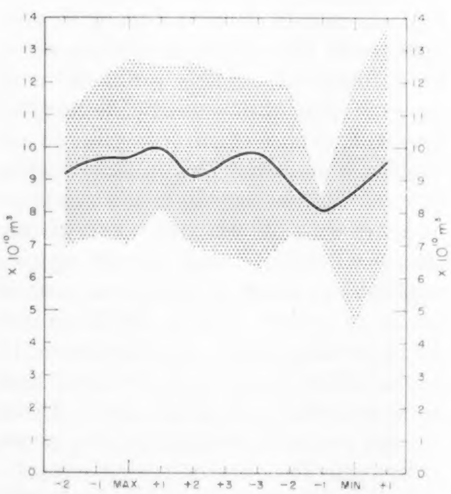



FIGURE 3. Curve shows the average annual discharge (in 10 billions of cubic meters) of the Nile River during the past 8 sunspot cycles. The years within the cycle are indicated as abscissas. The shaded area around the curve shows how widely the river discharges have varied in individual years from the mean value.

# Difficult Concepts in Beginning Chemistry

By GRANT W. SMITH

Director of General Chemistry, The Pennsylvania State University, University Park, Pennsylvania

FOR a college chemistry teacher to offer suggestions to a group of high school science teachers about teaching the high school chemistry course may seem presumptive. It is similar to the Monday quarterback who advises the football coach how he *should* have played last Saturday's game. I have not taught a high school course, but I have taught hundreds of college freshmen their first course in chemistry, and many more hundreds their first college course in the subject immediately following their high school course. Furthermore, I have done considerable work with high school teachers. Finally, I have been teaching chemistry for a long enough time to have seen the field grow in depth and complexity, year after year, until now a major revolution in organization and curriculum content is long overdue and sorely needed.

While this article will deal mainly with problems of the teaching of beginning chemistry, the same type of difficulties characterize other elementary science courses. Two kinds of difficulties which confront the chemistry teacher may be referred to as (1) general or background, and (2) the specific conceptual difficulty. Background difficulties must be recognized and considered in planning the teaching program; they can be resolved effectively and automatically by the competent teacher. Specific conceptual difficulties may be alleviated through appropriate methods of handling troublesome course topics through appropriate introductory material and definitions.

By background difficulties we mean those attitudes and prejudices toward the study of chemistry which are held by a significant number of students before they first set foot in the classroom. What can a chemistry teacher do to overcome student fear, prejudice, lack of motivation, lack of self-confidence, deficient preparation, weak orientation?

Primarily, the teacher himself must be well trained in chemistry and must possess an adequate understanding of the relationship of chemistry and chemists to other fields. If he has no confidence in his own knowledge, he can scarcely instill a confident attitude in his students. Secondly, the teacher, with full recognition of the objectives of his course, must give careful thought and planning to all phases of the instructional process. In so doing, he must be aware of the necessity for proper orientation of beginning students to their new study, and make certain that these students are not lost or discouraged in the early stages of the course.

The chemistry student is learning not only the rudiments of a science, but at the same time, a large new vocabulary of "foreign" words and terms. As a chemistry teacher, you must consciously introduce terminology to your students in dosages and in a manner which they can follow with understanding. This is not easy. Each technical term must be introduced meaningfully; it must be used over and over again in the same manner; and the students themselves must use it until it becomes an integral part of their language.

In connection with language difficulties, consider the matter of definitions. Students are often inclined to believe that the best definition is always the ready-made one in the textbook, or the one given by the teacher. Instead of employing memorization, students should be encouraged—perhaps com-

pelled—to express definitions and concepts in their own words. It is most important that the student has a clear understanding of the subject regardless of his ability to express it in the most elegant manner possible. If he understands it, he can use it, while his self-expression can be improved with training and practice.

**Specific Conceptual Difficulties**

To visualize that which is optically invisible is a difficult process for the novice chemist. If he is consistently unsuccessful in his attempts to understand the concepts and materials he is studying, his interest becomes passive, and he is likely to give up. As a result, the chemistry teacher is compelled to plan the presentation of his subject by (1) omitting all materials not serving a useful purpose, and (2) presenting all relevant materials as systematically as possible. A basis for decision might be these questions: Is this material helpful in achieving a clear understanding of the basic concepts essential to an introductory course? Or is it more likely to confuse and complicate the learning process? Using these criteria, I would certainly exclude the general acid-base theory, activity and activity coefficient, calculations of chemical equilibria, and the concept of the hydrogen bond, to name a few. I would include as pertinent, interesting materials, suitable examples which tie the study of chemistry in with everyday living and personal experiences. This type of material offers much of the "spice" of the course and leads to a better understanding of the more abstract concepts. The principles of combustion apply not only to hydrogen and oxygen, but to the operation of the Bunsen burner, the campfire, the furnace at home, and even to the oxidation of "fuels" in the body of the student.

The second principle for guiding the teaching of introductory chemistry is that material should be presented systematically, not as isolated facts. So far as possible, topics should be related to one another and to basic principles as the branches and twigs of a tree are related to the trunk. As the fundamental unifying concept, i.e., the trunk of the tree, I believe the structure of matter is the most logical one at the present time. The most direct and accurate interpretation of behavior of substances and the best understanding

Author demonstrates material to chemistry class through use of closed-circuit television.

of chemical principles are obtained in terms of modern concepts of atomic and molecular structure. The historical approach is too often a back-door approach. Historical material is of importance and interest for the understanding of the development of science and as a part of one's education and culture, but it is usually an illogical and rather inefficient way to study modern chemistry.

For illustration, consider the following question: Are the "laws of chemical combination" best understood when presented by the historical approach, or by recognizing them as mere corollaries of atomic theory? One can describe the experiments which over many years led to the statements of these principles; or one can devise and carry out experiments to demonstrate them to his own satisfaction. They still remain unexplained empirical relationships until we introduce the idea of the atomic theory. By the use of simple models representing two or three kinds of atoms, we can easily and conclusively show that the principles of Definite Composition, Multiple Proportions, and Combining Weights are simple results which follow automatically in this process once we accept the principle of atoms.

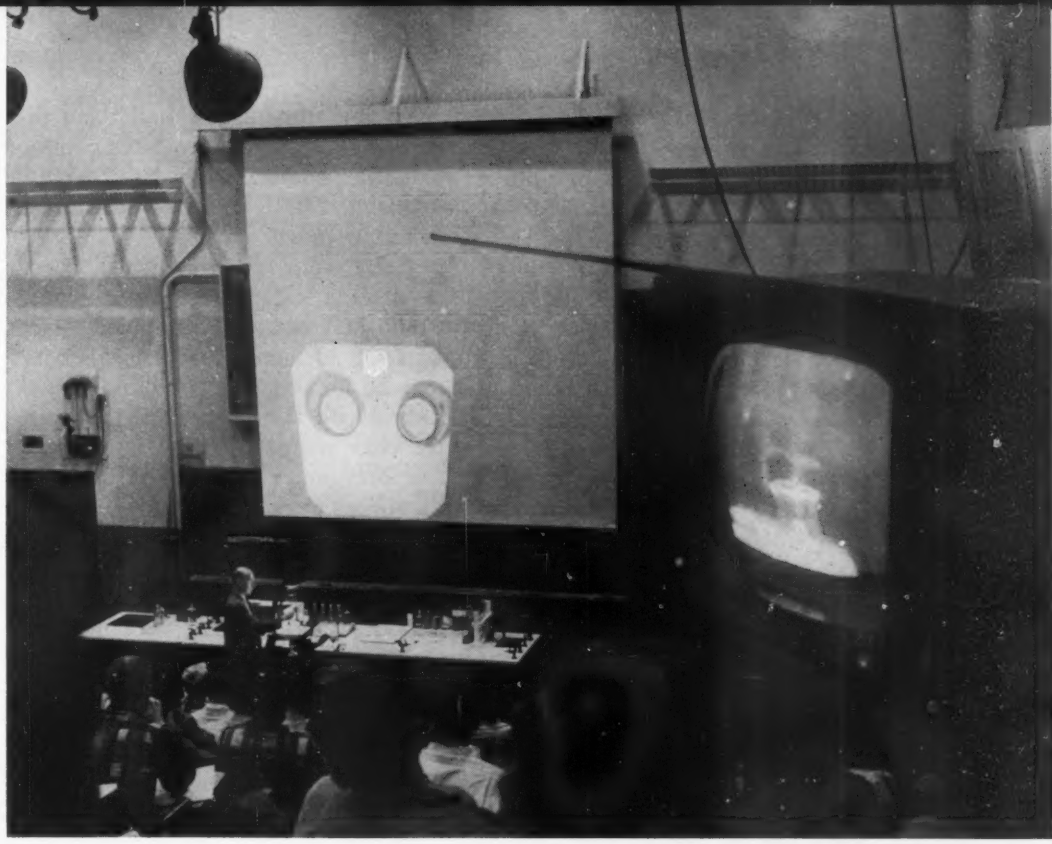
Introduce the unifying concepts of atomic and molecular structure and theory early in the course. Use only that amount of detail required to give a clear, but simple picture of our physical world composed of fundamental particles from which all atoms, molecules, and ions are formed. From this basic concept, once it is clearly understood in its simpler aspects, the other concepts of chemistry can be readily drawn and interpreted as the course develops. Among others, these include "laws" of chemical combination, periodic classification and relations, oxidation and reduction, chemical bonding, kinetic-molecular theory, nature of chemical reactions, equilibirum, and nuclear reactions. I do not propose treating these subjects beyond their simpler aspects in the introductory course. In more advanced courses, however, a similar systematic treatment will continue logically and successfully for the student with this background.

Let us look at some important specific areas of difficulty inherent in the teaching of chemistry. Knowledge of the behavior of gases is of great importance to the chemist or physicist. It is also important for purposes of a liberal education, for many common phenomena, such as combustion, respi-

ration, plant synthesis, etc., involve the gaseous state. Lack of knowledge of gases and their manipulation was a very strong retarding factor in the early development of science. Until simple principles of gaseous behavior were discovered by Galileo, Torricelli, Boyle, Charles, Priestley, Lavoisier, and others, gases were mysterious, confusing, contrary-appearing stumbling blocks to experimental progress. Once understood, scientific progress was rapidly accelerated.

It is common practice to introduce students to the subject of gases with the assumption that they already know what a gas is. Bear in mind that we are asking the student to become acquainted with materials he usually cannot *see*, cannot *touch*, cannot *hold*, cannot associate with definite *shape*, characteristic *size*, or any of the other criteria with which he is accustomed to associate familiar objects.

Before the student is ready to understand behavior of gases (gas laws), he must first know what a gas is. This knowledge should be imparted slowly in a series of well-planned experiences and thought developments leading to familiarity with these elusive substances. Consider the following suggested exercises and demonstrations:



Overhead projector is used simultaneously with closed-circuit television which gives direct view of reaction in experiment.

1. Start with solids and liquids which are more familiar and show relations to the gaseous state. Ice melts to water; water boils and becomes a gas; the gas condenses to water, a liquid. Iodine melts and sublimes; the vapor (gas) is visible (other colored gases—bromine, chlorine, nitrogen dioxide).
2. Demonstrate the presence of the atmosphere around us. Blow on fingers to "feel" it. Show how a sheet of paper "glides" through the air when dropped. Blow up a toy balloon (recall the pumping of air into a tire). Evacuate a gallon varnish can to show pressure of atmosphere.
3. Demonstrate diffusion phenomena by introducing some liquid bromine into an evacuated vessel. Repeat, using a similar vessel containing air at ordinary pressure.
4. Demonstrate thermal expansion of gases by cautiously heating a stoppered can and blowing out the stopper.
5. Demonstrate "barometer tube" of mercury. Try to make a similar barometer tube using water. Explain these phenomena in terms of the pressure of the atmosphere supporting the column of liquid. Compare with soda straw syphon. (Do not use the term "suction" in discussing these phenomena.)
6. Show how gases can be trapped and manipulated. Demonstrate collection of gases by upward and downward displacement of air, and over water. Show or describe measurement of gases by weight and by volume (pressure and temperature controlled).

With a planned campaign of demonstrations and experiences, the student will subconsciously acquire an understanding of the nature of gases. He now has the basis for learning the quantitative aspect of the behavior of gases. Throughout all of this, the kinetic molecular picture of gases should be instilled into his mental imagery. He should think of gaseous pressure and temperature in terms of molecules moving almost without restriction in space. The motion of these particles results in the effects we term pressure and temperature.

Matter should be portrayed from the structural viewpoint, in terms of electrons, protons, and neutrons. If a simple, clear atomic structural concept is acquired early in the course, the foundation for much basic chemistry is laid. By employing models, diagrams and suitable demonstrations, the picture of the atom as a structure composed of a dense nucleus associated wtih a definite system of electrons may be readily conveyed to students' minds. It is very difficult to teach atoms and molecules without using models, for the concepts of the nature of matter are highly abstract, even though logical.

Once a student has grasped a simple picture of the atom, he has acquired a basic, but very useful method for understanding periodicity of properties, and hence, the periodic classification of elements. While the introductory course in high school cannot pursue the relationship between periodic system and structure in too great detail, the student is now in a position to understand one of the most useful, interesting, and important simplifying classifications in the scientific field. He can now appreciate the importance of the octet or inert gas structure in the world of chemical reaction. He can now understand the best available simple basis for classifying metals and nonmetals. He can now picture the formation of chemical bonds between atoms, since, by use of models or simple drawings, the sharing or transfer of

valence electrons may be graphically portrayed and understood.

Care must be exercised in all of these portrayals to avoid oversimplification which leads to implanting of false ideas: e.g., carbon atoms are little black balls; or electrons sit like little dots on a circle around a black center; or atoms are two-dimensional. It should be clear to all that models and diagrams are at best but a crude, simplified representation of something which we cannot describe completely even in complex mathematical symbolism. The extent to which the teacher treats these structural concepts and related principles of chemical bonding and periodic classification depends upon his estimate of the capacities and scientific interests of his students, as well as the course objectives.

"Valence" is a term which is rapidly and quite properly being abandoned because it has been used to represent too many things. As an adjective, it does seem to find proper use (valence electron, valence number, valence bond). The preferred term for expressing the oxidation state of an element or radical is "oxidation number." ("Valence number" is also acceptable.) The oxidation number may be positive, negative, or zero; it is properly applied to atoms, ions, or radicals; it may easily be assigned to atoms either electrovalently or covalently bonded. Stress the fact that oxidation numbers are based on certain arbitrarily assigned values for key elements. In this way they somewhat resemble atomic weight scales, temperature scales, electrode potentials, and many others. When we assign an oxidation number of $+6$ to sulfur in sulfate, we do not imply that the sulfur atom has been stripped of its six valence electrons nor that it has an actual charge of six positive units.

**Writing Formulas**

Simple formula writing becomes almost automatic for one who has learned the oxidation numbers of common ions and radicals. This skill is easily acquired by even the least capable high school chemistry student. Without correct formulas, it is impossible to write equations, work problems involving formulas, or to appreciate the quantitative nature of chemistry. To impress students with the importance of writing correct formulas, I have often resorted to a simple teaching device. I have given the students, or had them prepare, a list of the elements and common oxidation numbers considered essential —about 15-20 cations or positive elements or radicals and 10-15 anions or negative elements or radicals. In each of several successive class periods I would take about five minutes to read a list of 20 names of chemicals which may be formed by combinations of the radicals on the master list, while the students write the 20 corresponding formulas on a ruled strip of paper with numbered lines. Papers may be quickly graded in class by the students or outside by the teacher. Each day, the formulas most frequently missed the previous day, together with new ones making up a list of 20 are given in the same way. As soon as most students are acheiving nearly 100 per cent on these short quizzes, the device is abandoned. This method should not be used too early in the year, but only after sufficient background has been obtained so that the significance and use of formula writing can be appreciated.

Balancing equations is a related operation which must be understood by the beginning student. Balancing of simple equations is usually learned readily by students. I seriously question the advisability of teaching special devices for balancing the more complex oxidation-reduction equations in the high school course. Students who have been taught a certain method in their high school course are often strongly prejudiced against learning any other method. Special devices should be omitted, except perhaps in advanced courses with exceptional students.

What about the phenomenon of oxidation-reduction itself? The basic principles of this process should be taught in the high school course because of their great importance; life itself depends upon such processes. It would seem the best way to proceed might be to reserve the presentation of oxidation-reduction until the students have a sufficient background of factual and theoretical knowledge so that the concept can be presented in its general form, i.e., in terms of gain or loss of electrons, or change in oxidation state. Special cases will then become normal examples of general behavior, and confusion of terminology will not be present. The following phenomena may well be included in an oxidation-reduction presentation: (1) reactions of metals and nonmetals with oxygen; (2) reduction of certain oxides by hydrogen; (3) reduction of hydrogen ion in acidic solution by active metals; (4) action of oxidizing acids, such as nitric acid, on copper and similar metals; and (5) simple oxidation and reduction reactions in electrolysis. Without complicating matters these phenomena can all be made meaningful in terms of the general concept of oxidation and reduction for high school courses.

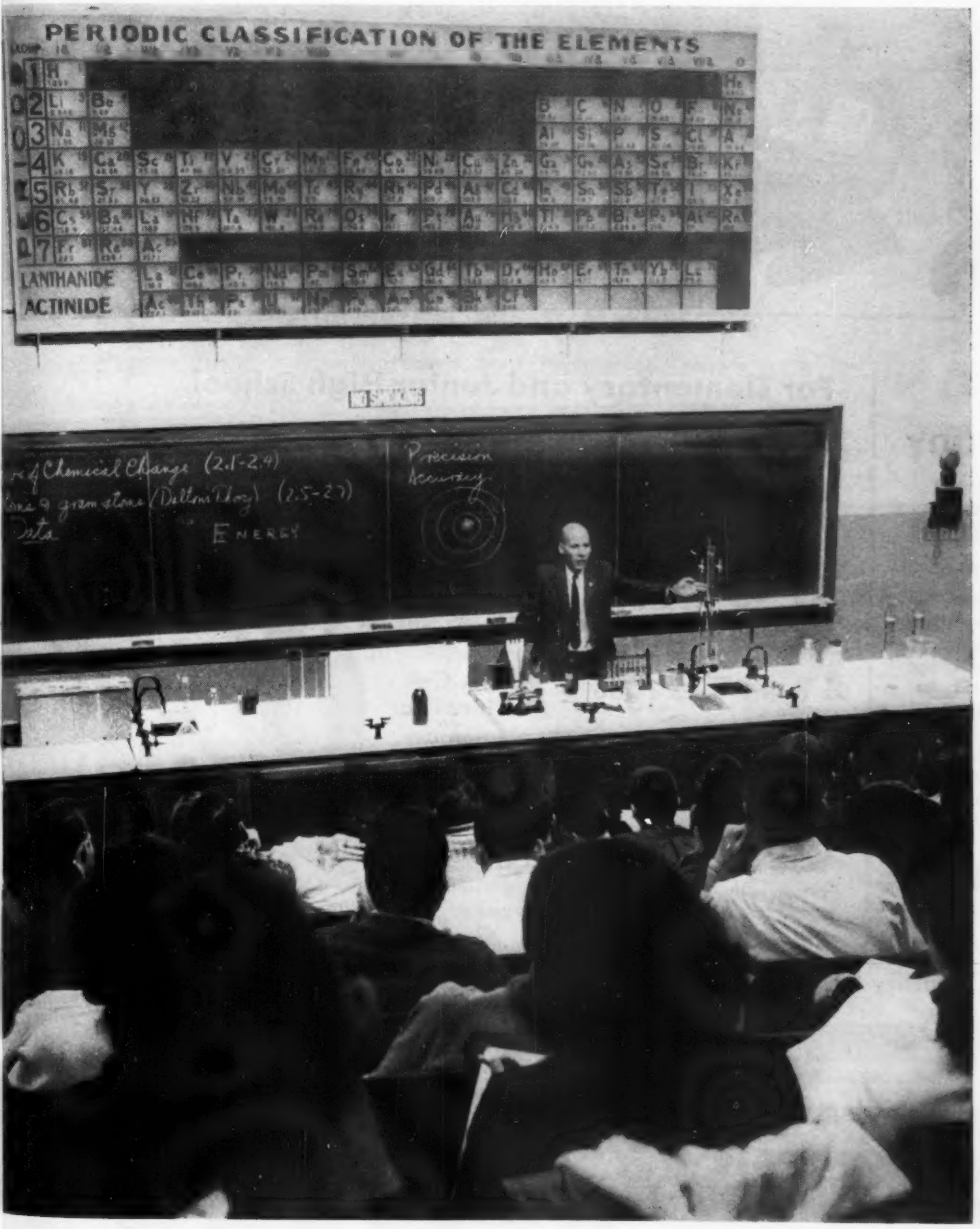
Student works with balance in laboratory used for freshman chemistry studies.

One of the most difficult concepts to teach in general college chemistry is that of chemical equilibrium. In many years of teaching the course, I have not yet found nor heard of anyone who has found the ideal way to put this concept over effectively. Mathematical formulations are involved in a more advanced treatment, but the high school course does not generally treat equilibrium quantitatively. High school courses do involve understanding the nature of a dynamic equilibrium system and should include qualitative predictions of change produced by variations in pressure, temperature, and concentration (Le Chatelier's Principle). If a clear and accurate conceptual picture of a system at chemical equilibrium is achieved by the student, then Le Chatelier's Principle can be truly *understood* by the student, and does not become a mere memorized combination of words and phrases. The teacher can feel justifiable pride in these results.

Analogies, diagrams, and animated cartoons all fall short of giving an accurate picture of the system at equilibrium, yet some can be quite helpful. One trouble with the analogies often used is that they show the forward and reverse reactions occurring between two separate regions, and attempt to show migration from one region to the other. I used one like the following for years. Two groups of men are placed on opposite sides of a line. If the same number of men per second move across the line in one direction as move per second in the opposite direction, the numbers of men in the two groups do not change, i.e., the system is at equilibrium. This is truly a type of equilibrium, but it is not a good analogy to leave in a student's mind as a representation of chemical equilibrium. Its usefulness, if any, would be in the preliminary discussion in which the meaning of the general term "equilibrium" is explained.

Most analogies and diagrams have the same gross fault: "reactants" and "products" are spatially separated into two distinct regions. The chemical equilibrium equation gives the same false picture because of the separation into "two sides of the equation:" $A + B \rightleftarrows C + D$. No wonder the student soon talks in terms of the two sides of the reaction! Students should be reminded that since "products" and "reactants" in a chemical system at equilibrium are completely and hopelessly mixed, it is impossible to change temperature, or pressure, or anything else for the reactants without doing the same to the products.

Author lectures to beginning chemistry class interpreting definitions and relating uses of equipment to experiments described.




A better analogy, but still an imperfect one, is that proposed by W. E. Caldwell in 1932, the "dance floor analogy." One thousand couples appear on the dance floor wearing white and one thousand appear in black. They begin dancing. Originally, the couples are of two types (reactants), $M_wL_w$ (men and ladies in white) and $M_bL_b$ (men and ladies in black). When they collide, they exchange partners: $M_bL_b + M_wL_w \rightleftarrows M_bL_w + M_wL_b$. Eventually equilibrium will be reached; in this case, when all four concentrations are equal.

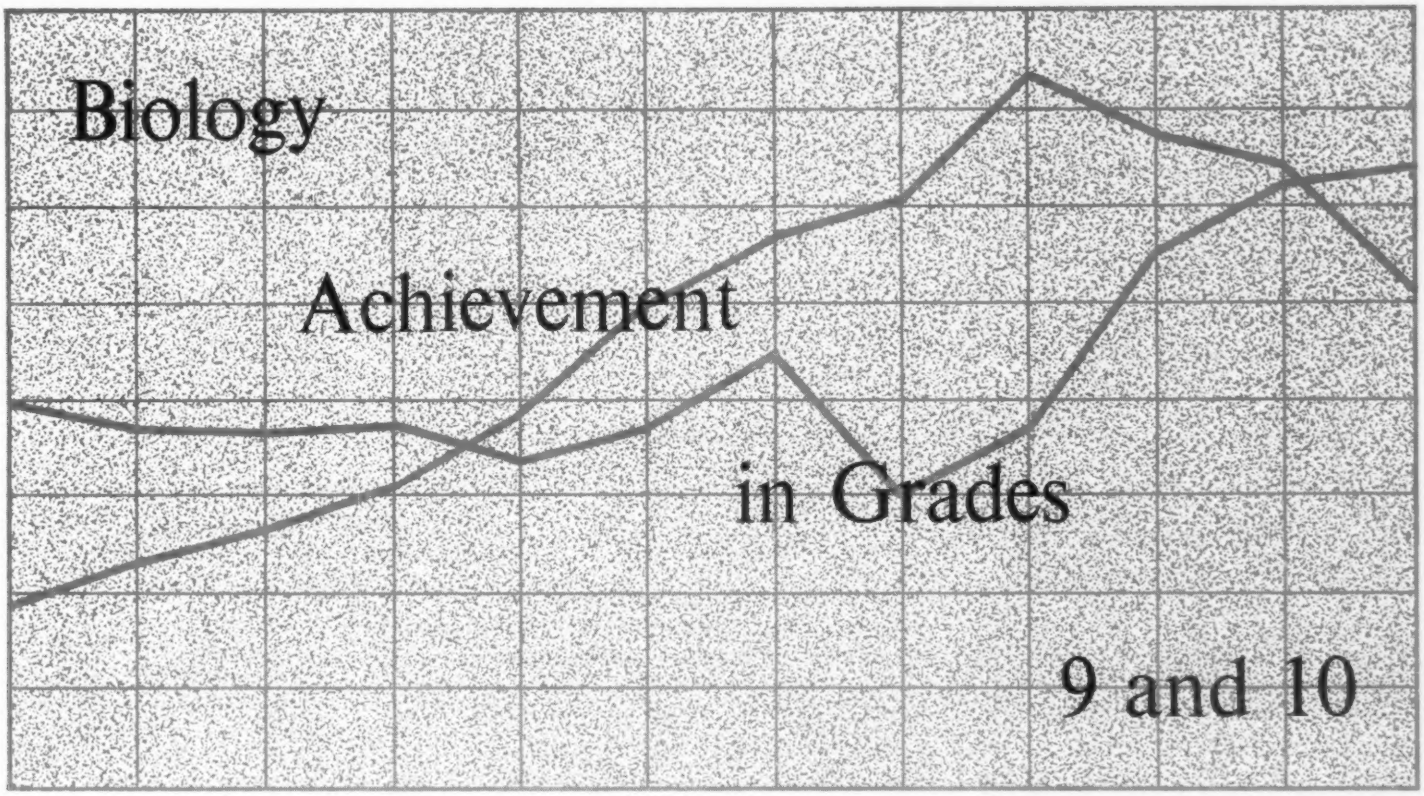
Various changes in conditions can be introduced which will effect the equilibrium conditions, or speed of reaching equilibrium.

1. If "hot" or fast music is played by the orchestra, collisions will be more frequent and equilibrium will be reached more quickly (effect of increase in temperature on rate of reaction, or effect of catalyst, in this case the orchestra).
2. If we impose the condition that "dark gentlemen prefer blondes," then all $M_bL_w$ couples stroll into the garden one by one, and the reaction, in effect, proceeds to completion as in the reversible chemical system in which one of the products is effectively removed from the system as a gas or precipitate.

Other interesting analogies can be drawn by changing the condition of the example, yet at best it is still a very imperfect analogy.

It is quite impossible to discover the one "best" way to teach any particular concept in chemistry. What is best for one teacher may not be best for another. There are, however, certain problem areas of instruction in beginning chemistry which can be identified readily. Every teacher must carefully plan his presentation, and then continually observe the progress and reactions of his students to make sure that he is planting correct ideas in their chemical understanding.

# Biology Achievement in Grades 9 and 10



**Report of Test Scores in Biology by Students in the Denver Public Schools**

By GEORGE E. MATHES

Director of Science, Denver Public Schools, Colorado

and SAM BLANC

Coordinator of Instruction, Denver Public Schools, Colorado

**This report and the article following by L. H. Heidgerd represent two studies which yield conflicting evidence on the question: At what grade level should a course in general biology be placed?**

ONE of the unsettled questions in science education has been the grade placement of general biology. Traditionally a senior high school course, some authorities have indicated that biology could be taught in junior high school to selected ninth-grade pupils. In order to validate this hypothesis, the Denver Public Schools offered a course in biology to selected pupils in grade nine in five junior high schools during the school year 1958-1959, and compared results with unselected high school pupils in grades ten, eleven, and twelve and with an equated group of tenth-grade pupils. This report is therefore a summary of the pilot study.

### Purpose of the Study

The purpose of the study was to compare the achievement of selected ninth-grade students with the achievement of high school students in general biology, as measured by a test of general biology developed by Denver science teachers.

### Development of the Measuring Instrument

The test was developed by a committee of junior and senior high school biology teachers. Content was based on the approved course of study in use in the Denver Public Schools. The questions sampled the student's understanding of factual information and certain laboratory experiences from each of the units included in general biology. The test consisted of two parts and took two class periods to administer. Part I consisted of ninety multiple-choice questions designed to measure the student's ability to recall certain facts, principles, and concepts. Part II consisted of forty multiple-choice questions designed to measure the student's ability to generalize from certain laboratory experiments. The test was administered to all second semester biology pupils in the junior and senior high schools near the end of the school year. The total number of pupils taking the test by grade level and sex is given in Table I.

### Schools and Pupils Involved in The Study

The study involved most of the students taking biology in junior and senior high schools during the second semester of the 1958-1959 school year. The senior high school pupils in the

study were those who were enrolled in the standard biology course. The junior high school pupils were those who were completing the same course in grade nine. These ninth-grade biology students were selected on the basis of their interest in science and in science-related careers, their ability as measured by a standardized intelligence test, their grades in academic subjects, and the recommendations of their science and counseling teachers. The high ability of the ninth-grade group can be seen from the distribution of scores on the Otis Test of Mental Ability. Table II reports the range and interquartile scores.

### Comparison of Selected Ninth Grade Pupils with Unselected High School Pupils

Since the test was given to practically all ninth-grade and high school pupils taking biology, it was possible to compare scores of the two groups. A comparison between the measures of central tendency and range indicated that the ninth-grade pupils did substantially better than the high school pupils. This was to be expected since ability was one of the factors in selection of the ninth-grade pupils. Table III compares the measures of central tendency and gives the range of the two groups.

**TABLE I**
**Number of Pupils Participating in the Study by Grade Level and Sex**

| GRADE LEVEL | BOYS | GIRLS | TOTAL |
|---|---|---|---|
| Junior High School, Grade 9 | 143 | 56 | 199 |
| Senior High School, Grade 10 | 415 | 393 | 808 |
| Senior High School, Grade 11 and 12 | 159 | 281 | 440 |
| Total | 717 | 730 | 1,447 |

### Comparison between Equated Ninth and Tenth Grade Pupils on Parts I and II of the Test

#### Matched Groups

An attempt was made to equate the ninth-grade pupils with an equal number of tenth-grade pupils and compare the scores made on the test. This was accomplished using all of the 199 ninth-grade group and selecting an equal number of boys and girls with almost identical IQ's from the group of tenth-grade test results. The ninth-grade Otis IQ score was used for both groups. The range and measure of central tendency for the two groups are given in Table IV. The two groups are so similar that for all practical purposes they may be said to have equal ability.

**TABLE II**

**Range and Measures of Central Tendency for Pupils Taking Biology in Grade Nine as Measured by The Otis IQ Test (199 Pupils)**

| | BOYS | GIRLS | TOTAL GROUP |
|---|---|---|---|
| $Q_3$ | 127.0 | 121.0 | 124.0 |
| Median | 119.0 | 115.3 | 118.5 |
| $Q_1$ | 112.4 | 112.0 | 112.3 |
| Range | 101-142 | 101-133 | 101-142 |

**TABLE III**

**A Comparison Between Selected Ninth Grade Pupils and High School Pupils on Parts I and II of the Test (Perfect Score = 140)**

| | NINTH GRADE | HIGH SCHOOL |
|---|---|---|
| $Q_3$ | 106.0 | 94.0 |
| Median | 97.5 | 82.5 |
| $Q_1$ | 87.5 | 70.0 |
| Range | 59-128 | 25-125 |

Pursuing science avidly, ninth-grade girl student ranks high in ability and performance.

ATLANTA PUBLIC SCHOOLS

### Part I of the Test

Studies of the two matched groups were made for boys and girls on Parts I and II of the test. One hundred forty-three boys and fifty-six girls participated in this phase of the study at both ninth- and tenth-grade levels. Part I of the test consisted of ninety questions. In general, boys did better than girls in both the ninth and tenth grade. The

**TABLE IV**

**Range and Measures of Central Tendency between Ninth and Tenth Grade Pupils Matched on the Basis of Sex and Scores on The Otis Test of Mental Ability (143 Boys — 56 Girls)**

| | NINTH GRADE | | TENTH GRADE | |
|---|---|---|---|---|
| | BOYS | GIRLS | BOYS | GIRLS |
| $Q_3$ | 127.0 | 121.0 | 125.3 | 121.0 |
| Median | 119.0 | 115.3 | 119.6 | 115.3 |
| $Q_1$ | 112.4 | 112.0 | 112.4 | 112.0 |
| Range | 101-142 | 101-133 | 101-138 | 101-133 |

**TABLE V**

**A Comparison of Measures of Central Tendency and Range for Matched Groups of Ninth and Tenth Graders on Part I of the Test (143 Boys — 56 Girls. Perfect Score — 90)**

| | NINTH GRADE | | | TENTH GRADE | | |
|---|---|---|---|---|---|---|
| | BOYS | GIRLS | TOTAL | BOYS | GIRLS | TOTAL |
| $Q_3$ | 71.7 | 66.0 | 70.8 | 69.7 | 65.4 | 67.2 |
| Median | 66.5 | 60.5 | 64.4 | 61.9 | 56.5 | 61.2 |
| $Q_1$ | 58.8 | 58.3 | 56.3 | 56.4 | 49.5 | 52.7 |
| Range | 42—89 | | | 41—85 | | |

interquartile range for the ninth-grade group was 56.3 to 70.8 and for the tenth-grade group, 52.7 to 67.2. The range of scores is almost the same but the top scores for the ninth-grade group are higher than for the tenth-grade group. Likewise, the low scores in the tenth-grade group are below those for the ninth-grade group. This would indicate that the ninth graders, in general, did better on Part I of the test than did their matched tenth-grade counterparts. Data are given in Table V.

**Part II of the Test**

Part II of the test consisted of forty questions. Again boys did slightly better than girls in both groups. The range of

scores in the ninth-grade group was from 17 to 40 correct, and for the tenth-grade group from 19 to 40 correct. The median score for grade nine was 35.1 and grade ten 33.2. This may indicate that again ninth-grade pupils did slightly better on Part II of the test than tenth-grade pupils. The high scores made by both groups on Part II of the test may indicate that both groups learned how to generalize and apply the principles of biology equally well. Data for range and measures of central tendency for Part II of the test are given in Table VI.

### Summary

On the basis of a study of the scores on the total test for the matched groups of ninth- and tenth-grade students, it would seem that selected ninth-grade pupils can achieve as well, and in some instances better, than tenth-grade pupils of comparable ability in general biology. In Part I of the test the differences among the three measures of central tendency used are probably large enough to have some statistical significance. In Part II the large number of scores may indicate that the test was not difficult enough for the higher-ability pupils. Consequently, the difference between the two groups was not so great and may not be a significant difference.

### Conclusions

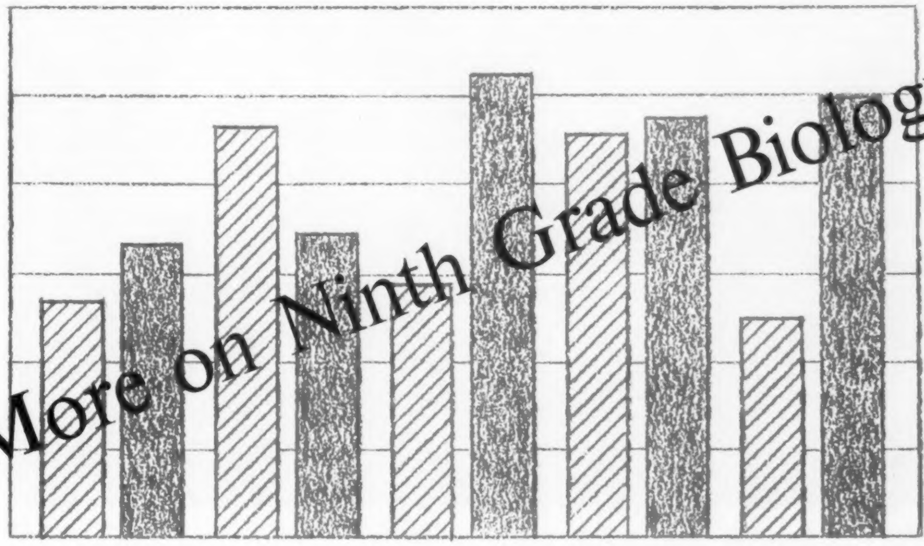
This pilot study was established to test the assumption that selected ninth-grade students could do as well as tenth-grade students in a course in general biology. The data reported here point out clearly that the group of ninth graders selected on the basis of ability, interest in science, and teachers' recommendations did considerably better than unselected high school students. When compared with a group of tenth-grade students selected to match the ability of the ninth grade, ninth-grade students did slightly better than the tenth-grade group. Boys did slightly better than girls in both groups.

**TABLE VI**

**A Comparison of Measures of Central Tendency and Range for Matched Groups of Ninth and Tenth Graders on Part II of the Test (143 Boys — 56 Girls. Perfect Score — 50)**

| | NINTH GRADE | | | TENTH GRADE | | |
|---|---|---|---|---|---|---|
| | BOYS | GIRLS | TOTAL | BOYS | GIRLS | TOTAL |
| $Q_3$ | 37.3 | 35.6 | 36.1 | 37.1 | 34.9 | 35.7 |
| Median | 35.2 | 32.9 | 35.1 | 33.3 | 33.1 | 33.2 |
| $Q_1$ | 31.9 | 29.8 | 31.2 | 31.7 | 29.3 | 29.8 |
| Range | 17—40 | | | 19—40 | | |

# More on Ninth Grade Biology



**Summary of a Doctoral Thesis completed at the University of Illinois**


**By LLOYD H. HEIDGERD**

Associate Professor of Science, State University College of Education, Buffalo, New York


SHOULD required ninth-grade general science be eliminated and replaced with required ninth-grade biology? This is a question which is receiving some considerable attention. A number of reasons have been advanced for considering this move. Among them are: (1) Ninth-grade general science is often repetitious of upper elementary or early junior high school science; (2) Radio, television, and the wide distribution of popular science books and magazines have increased the general science knowledge of most youngsters; and consequently (3) Many youngsters are bored by the customary ninth-grade general science course; and (4) These are not times to waste effort in science education.

Arguing positively, it has been held that high school students would obtain a higher average level of science knowledge if ninth-grade biology were introduced, particularly if it were followed by a tenth-grade physical science course. A two-year general science sequence would be established without the boring repetitions and consequent ineffectiveness of seventh- and eighth-grade general science in ninth-grade general science and the unnecessary duplication of the biology unit of ninth-grade general science in tenth-grade biology. This argument, of course, assumes that the present practice of the majority of students taking two years of science continues. According to government figures aproximately 75 per cent of the U. S. tenth-grade population is enrolled in biology (1). Assuming now that tenth-grade physical science is offered, it can further be reasoned that weak science students would be either eliminated from taking physics or chemistry or better prepared for those courses by their experience in tenth-grade physical science. In effect, standards in chemistry and physics could be raised. Moreover, well-qualified students could be excused from the physical science course if they included chemistry and physics in their course plans. This would allow room for an advanced science or a course of interest in another subject matter area.

The study which is summarized in the following paragraphs was an attempt to get data on some of these arguments. The approach used made practical an investigation possessing some notable differences from previous studies of the same or similar curriculum changes. Among these differences were: (1) More teachers were involved—four biology, three physical science, and three physics teachers; (2) The achievement of a relatively large number of students, over 425 in biology alone, was evaluated; and (3) Total school populations were included.

Suitable measuring instruments and standards based on the common, contemporary high school science curriculum were provided when the World Book Company made available the complete standardizing samples for the general science, biology, and physics tests in its *Education* and *Adjustment* series (2). From the company's data the mean scores obtained by the students of each school used in the standardizing samples of the achievement tests were computed. These mean achievement scores were then adjusted to a common IQ* and empirical distribu-

*Regression coefficients of achievement against IQ were computed, and the mean achievement scores all adjusted to a single IQ according to the slopes of the regression lines.

tions of school achievement means constructed. These three distributions, one for each of the subject matter tests, were the standards against which the schools offering ninth-grade biology were compared.

Two schools had been located which were offering ninth-grade biology and tenth-grade physical science. The method of school selection introduced a bias since schools pioneering in curriculum change would be likely to have a better-than-average faculty and administration, but such, or an equivalent, bias was unavoidable. Students in the two schools were given the appropriate achievement tests at the end of the school year, mean scores were computed for various groups of students within each school, and these means adjusted to the common IQ to which the comparison distributions of school means had been adjusted.

Now to move to the testing of some of the values which it was thought would be fostered by the change in curriculum. Underlying the advocacy of ninth-grade biology is the assumption that ninth graders will do as well in biology as tenth graders. The first problem was to test this assumption. This was done using the standardizing sample of the *Nelson Biology Test* modified to include tenth-grade students only.

The adjusted ninth-grade biology mean for the 303 students in one school, which we will call School A, ranked 51 from the top among the 60 schools in the standardizing distribution; the 124 students in the second school, which we shall call School B, ranked 57 from the top. When the students of School A and School B were grouped according to their teachers, the results shown in Table I were obtained. The students in School B could not be


BROOKS PHOTO, BETHESDA, MARYLAND

Achievement is important in laboratory procedures as well as in written test scores.

**TABLE I**

**Ranks of Student Groups According to Teachers on the *Nelson Biology Test***

| Teacher | 1 | 2 | 3 | 4[a] |
|---|---|---|---|---|
| Rank | 55/60 | 42/60 | 57/60 | 57/60 |
| Number of Students | 115 | 101 | 87 | 124 |

[a]Taught all students in School B

**TABLE II**

**Differences between Expected Mean Scores and Obtained Mean Scores on the *Nelson Biology Test***

| Teacher | 1 | 2 | 3 | 4[a] |
|---|---|---|---|---|
| Obtained Mean Score | 111 | 113 | 111 | 106 |
| Expected Mean Score | 116 | 116 | 117 | 113 |
| Difference | −5 | −3 | −6 | −7 |
| Number of Students | 115 | 101 | 87 | 124 |

[a]All students in School B

divided because only one teacher was involved. As can be seen, the classes of three of the four teachers ranked 55 or further from the top among the 60 school means.

To clarify the meaning of this low ranking, Table II shows how many standard score points the mean scores lay below what would be expected according to the mean intelligence quotients of the groups, assuming the schools were average schools.

It should be pointed out that the expected mean of all students on the test is 104 and that the higher expected means here indicate that the students used for this research had high average ability.

Using the concept of the standard error of estimate based on the regression of acheivement upon IQ, these groupings of students were 1.7, .97, 1.7, and 2 standard errors of estimate below prediction. Thus three of the four groupings of students turned out to have obtained mean achievement scores which were lower than would be expected of 95 per cent of similar groups of students, and all were below prediction. These data did not produce statistically significant differences since the extensive variability of the large control sample did not permit such a determination.

Assuming then that the most determinative data available under the present state of knowledge indicates that achievement in biology is less at the ninth-grade level than at the tenth-grade level, is the difference large enough and of such a nature as to be educationally important? The answer to this question is largely a judgmental matter. Though such information as is presented in Table II is helpful, the answer would also depend on how well other educational objectives had been reached. It is possible that the loss in achievement might be compensated for by other educational gains.

I shall now turn to an examination of two such possible gains which were assumed to have been obtained from introducing ninth-grade biology in the two schools involved in this investigation. The hypothesis was made that ninth-grade biology and tenth-grade physical science would lead to a better knowledge of general science since the students who completed both courses would have had a two-year course in general science. This hypothesis was tested with the *Read General Science Test* at the end of an elective tenth-grade physical science course. The results are shown in Table III.

**TABLE III**

**Ranks of Mean Scores of Groups of Students after Ninth Grade Biology and Tenth Grade Physical Science Using the *Read General Science Test***

| Teacher | 1 | 2 | 3[a] |
|---|---|---|---|
| Adjusted Rank | 24/57 | 28/57 | 5/57 |
| Number of Students | 98 | 21 | 31 |

[a]Students in School B

The results given in this table do not support the hypothesis except perhaps in the case of Teacher 3 where one must keep in mind that this is an instance where the teacher factor probably entered the picture. The students of this teacher might have done just as well had they just finished the ninth-grade general science course with him. In fact, the students of teachers in five schools out of the 57 in the test standardization group did perform just as well or better.

The hypothesis that high school physics students would do better work in schools offering ninth-grade biology and tenth-grade physical science was tested in the same manner as were the other two hypotheses except that the *Dunning Physics Test* was the instrument. Here the results were encouraging as is shown in Table IV.

**TABLE IV**

**Ranks of Mean Scores of Groups of Students after a Physics Course in the Eleventh or Twelfth Grade Using the *Dunning Physics Test***

| Teacher | 1 | 2 | 3[a] |
|---|---|---|---|
| Adjusted Rank | 38/42 | 1/42 | 7/42 |
| Number of Students | 25 | 26 | 70 |

[a]Students in School B

Teacher 1 had a low ability class most of the members of which probably should not have taken physics, or if they had done so, they should not have been rated on the basis of the test used. If one accepts this exception and looks upon the results as encouraging, it must be kept in mind that again they are not statistically conclusive. They do, however, point out that the ninth-grade biology, tenth-grade physical science sequence is not inimical to high achivement classes in physics.

On the whole the trends of results

Experiments planned for each grade level should be evaluated in terms of the objectives of the entire course.

BROOKS PHOTO, BETHESDA, MARYLAND

were negative toward the plan of ninth-grade biology and tenth-grade physical science. And, two sources in the literature reinforce this picture (3,4).

The limitations of the findings of this study illustrate the difficulty of evaluating a going-school situation objectively. One obvious limitation was the use of a single criterion test for each course. A statistical difficulty revolved around the problem that the many factors influencing test scores caused such a wide variability that the effects of the curriculum change alone could not be detected at a level which would be statistically significant.

In conclusion, it would seem that the change to ninth-grade biology and tenth-grade physical science should only be made if it is expected that there will be some loss in biology achievement and that other gains will make the change worthwhile. Since local factors, such as teacher interest, may greatly affect the success of the new program, it should be evaluated in terms of local objectives after giving it enough time for a fair trial. Inherent in the concept here presented is that the findings might indicate a return to the old program or a shift to another new program.

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The Times

LONDON, MONDAY, DECEMBER 26, 1859.

DARWIN ON THE ORIGIN OF SPECIES.*

There is a growing immensity in the speculations of science to which no human thing or thought at this day is comparable. Apart from the results which science brings us home and securely harvests, ...

But our knowledge of life is not confined to the existing world. Whatever their minor differences, geologists are agreed as to the vast thickness of the accumulated strata which compose the visible part of our earth, and the inconceivable immensity of the time of whose lapse they are the imperfect, but the only accessible witnesses. Now, throughout the greater part of this long series of stratified rocks are scattered, sometimes very abundantly, multitudes of organic remains, the fossilized exuviæ of animals and plants which lived and died while the mud of which the rocks are formed was yet soft ooze, ...

# Special Report on the Darwin Centennial Celebration

# ONE HUNDRED YEARS LATER


**By ABRAHAM RASKIN**

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On November 24, 1859, John Murray, publishers of Albemarle Street in London, issued the first edition of 1250 copies of a book whose first few sentences read as follows:

> I will here give a brief sketch of the progress of opinion on *The Origin of Species*. Until recently the great majority of naturalists believed that species were immutable productions, and had been separately created. This view has been ably maintained by many authors. Some few naturalists, on the other hand, have believed that species undergo modification and that the existing forms of life are the descendants by true generation of pre-existing forms.

This book was, of course, Charles Darwin's *The Origin of Species* by Means of Natural Selection or The Preservation of Favoured Races in the Struggle for Life. The edition sold out on the first day of issue.[1]

Charles Darwin (1809-1882) had been convinced that species were mutable by his observations during his voyage on *H.M.S. Beagle* (1831-1836), and he had been gathering facts in support of this theory since 1837. In 1842, he produced a 35-page pencil-written abstract of his theory and two years later, in the summer of 1844, he prepared a 230-page hand-written, first draft of the *Origin*. The writing of the *Origin* took but a little more than a year. The following comment by Darwin on his writing habits may be of interest to the reader.[2]

> Formerly I used to think about my sentences before writing them down; but for several years I have found that it saves time to scribble in a vile hand whole pages as quickly as I possibly can, contracting half the words; and then correcting deliberately. Sentences thus scribbled down are often better ones than I could have written deliberately.[3]

What kind of a man was Darwin? He was cautious, patient, modest, and self-critical. It was probably this combination of traits that was largely responsible for the delay in producing the *Origin*, and for the orderly, irrefutability of the evidence finally presented in the book. Eiseley says,

> The *Origin* and its author have a history which runs silently and mysteriously through twenty years of ill health, lone effort, and corroding doubt.[4]

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[1] A copy of a first edition of *Origin of Species* can be bought today for from $200 to $500, depending on condition. However, the reader is advised that a later edition, with a special introduction by Sir Julian Huxley, is available as a Mentor Book, published by the New American Library, and sells for 50¢.

[2] For a comprehensive insight into the life of Charles Darwin, the reader is referred to *The Life and Letters of Charles Darwin*, edited by Frances Darwin, Volumes I and II. Basic Books, Inc., New York. 1959. This book is the source on which all biographers of Darwin depend. It contains autobiographical recollections written by Darwin for his children. It was first published in 1888, reissued many times since, and was out of print for many years. The present issue is in recognition of the anniversary.

[3] *Life and Letters*, p. 80.

[4] Loren Eiseley, *Darwin's Century*, Evolution and the Men Who Discovered It. Doubleday and Company, Inc., Garden City, New York 1958. p. 142.

In accounting for his success, Darwin says:

My habits are methodical, and this has been of not a little use for my particular line of work. Lastly, I have had ample leisure from not having to earn my own bread. Even ill-health, though it has annihilated several years of my life, has saved me from the distractions of society and amusement.

Therefore my success as a man of science, whatever this may have amounted to, has been determined, as far as I can judge, by complex and diversified mental qualities and conditions. Of these, the most important have been—the love of science—unbounded patience in long reflecting over any subject—industry in observing and collecting facts—and a fair share of invention as well as common sense. With such moderate abilities as I possess, it is truly surprising that I should have influenced to a considerable extent the belief of scientific men on some important points.[5]

We get an insight into Darwin's methods from the following passage concerning an aspect of his voyage on the *Beagle*.

The investigation of the geology of all the places visited was far more important, as reasoning here comes into play. On first examining a new district nothing can appear more hopeless than the chaos of rocks, but by recording the stratification and nature of the rocks and fossils at many points, always reasoning and predicting what will be found elsewhere, light soon begins to dawn on the district, and the structure of the whole becomes more or less intelligible.[6]

Darwin's interest in natural history began rather early. At the age of eight he collected shells and minerals. His interest in collecting persisted, and, in his university days, he collected beetles as a hobby. His comments on methods of university teaching are noteworthy.

The instruction at Edinburgh was altogether by lectures, and these were intolerably dull, with the exception of those on chemistry by Hope; but to my mind there are no advantages and many disadvantages in lectures compared with reading.[7]

What was Darwin's contribution to the theory of evolution? It is well known that several of the early Greek philosophers had thought of the idea. Erasmus Darwin, the grandfather of Charles, wrote a poem called *Zoonomia* expressing the principle of evolution fifteen years before Charles was born. And in 1809, the great French biologist, Jean Baptiste Lamarck, described a fully worked-out evolutionary theory. Everyone is, of course, familiar with the work of Alfred Russel Wallace, a contemporary of Charles Darwin. Wallace, after expeditions in the Amazon Valley and the Far East, independently conceived the idea of natural selection. It was probably the knowledge of this discovery that stimulated Darwin to publish the *Origin*. Both men read their preliminary papers jointly at a meeting of the Linnaean Society in London in 1858.

Darwin's unique contribution was that he brought forth for the consideration of biologists, a storehouse of well-chosen facts which could be interpreted in only one way: in support of his theory of evolution and the mechanism of natural selection as the method of evolution. The *Origin* has been called a master synthesis. Waddington evaluates the influence of the theory of evolution in the following statement.

In its effect on man's general mode of thought about the world, the theory of evolution is at least as far-reaching as the most important earlier contribution of science, namely, Newton's laws of motion and concepts of mass and force.[8]

What is our position on evolution today? From 1859 until about 1925, Darwinism came in for a great deal of criticism. Since that time, Huxley summarizes,[9] a series of findings has resulted in the reconciliation of the apparent contradictions in Darwin's theory. These discoveries included the conclusive demonstration that acquired characters cannot be inherited; that continuous evolutionary change can be brought about by the accumulation of many, small, discontinuous mutations under the guidance of natural selection; the demonstration by R. A. Fisher in 1930 that heredity is particulate, i.e., dependent on distinct self-reproducing units or genes each of which could mutate into new self-reproducing forms; and the fact that most mutants are recessive.

Huxley says that,

Neo-Darwinism, as we may call the modern theory of gradual transformation, operated by natural selection acting on a Mendelian genetic outfit of self-reproducing and self-varying genes, is fully accepted by the great majority of students of evolution.[10]

Darwin gave us a new understanding and point of view. During the past one hundred years, scientists in many fields have engaged in research stemming from his discoveries and formulations.[11]

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[5] *Life and Letters*, p. 85-6.

[6] *Life and Letters*, p. 52.

[7] *Life and Letters*, p. 32-3.

[8] S. A. Barnett. *A Century of Darwin*. Harvard University Press, Cambridge, Massachusetts. 1958. p. 5.

[9] Charles Darwin. *The Origin of Species*. The New American Library (A Mentor Book), New York. 1958. (Introduction by Sir Julian Huxley), p. xii.

[10] *Ibid*, p. xiii.

[11] For an account of the progress made in several fields, the reader is referred to *A Century of Darwin*, edited by S. A. Barnett, Harvard University Press, Cambridge, Massachusetts. 1958. This volume consists of fifteen articles prepared by authorities on Darwin's contributions to evolution and to other fields ranging from embryology to botany, the social sciences, and ethics.

The Darwin Centennial Celebration, held at The University of Chicago during November 24-28, 1959, was organized to take stock of the contributions of the theory of evolution to human culture during the past century.

The Celebration was conceived four years ago by Professor Sol Tax of the Department of Anthropology of The University of Chicago. During the past three years, forty-three scholars from all over the world were invited to examine the particulars of evolution from the vantage of their own special disciplines, and to prepare papers on the present status of evolutionary doctrine. These papers were interchanged among the specialists, and were carefully read, criticized, and revised.[12] The papers were also studied by the Celebration Committee in Chicago. After two years of study, it became clear that the questions raised by the scholars could best be considered under five categories: The Origin of Life, The Evolution of Life, Man as an Organism, The Evolution of the Mind, and Social and Cultural Evolution. It was decided that each of these headings would serve as a subject for a separate panel discussion.

Among the forty-three scholars who prepared papers for the Celebration were: Marston Bates of the University of Michigan; MacDonald Critchley of the National Hospital, London; Sir Charles Galton Darwin, grandson of Charles Darwin; Th. Dobzhansky of Columbia University; Hans Gaffron of The University of Chicago; G. F. Gause of the U.S.S.R. Academy of Medical Sciences; Ralph W. Gerard of the University of Michigan; Sir Julian Huxley; Clyde Kluckhohn of Harvard University; Alfred L. Kroeber of the University of California, Berkeley; L.S.B. Leakey of the Coryndon Memorial Museum, Nairobi, Kenya; Hermann J. Muller of Indiana University; Alexander Van Muralt of the University of Berne; Fred Polak of the University of Rotterdam; Bernard Rensch of the University of Munster; Harlow Shapley of Harvard University; George Gaylord Simpson of Harvard University; N. Tinbergen of the University of Edinburgh; Leslie White of the University of Michigan; and Sewall Wright of the University of Wisconsin.

In the autumn of 1959, thirty members of the faculty and fifty selected graduate students from twenty departments of The University of Chicago studied the papers, and thought and talked through the issues in the study of evolution as seen under the five major headings. This group developed working documents that could serve as agenda for the five panel discussions.

The panelists, who were the authors of the original papers prepared for the Celebration, met several days before the start of the meetings to give final form to the agenda.

Some of the major questions listed in the agenda for the panel discussions are given below. In the time available, the panelists discussed many of the topics on the lists to determine whether there was general agreement, where qualifi-

[12] These papers will be published in 1960 by The University of Chicago Press in two volumes, entitled *The Evolution of Life*, and *The Evolution of Man*. These will be the first two volumes in a three-volume series entitled *Evolution After Darwin*, The University of Chicago Centennial.

cation was required, and where research was needed to resolve the questions that were at issue.

**PANEL I: The Origin of Life.**

The naturalistic view of life.
The fact of Darwinian evolution.
The origin of living things from non-living matter.[13]
The structure of nucleic acid.
The uniformity of modern life on earth in its basic metabolic reactions.
Can life originate under present conditions on earth?[14]
The probability of life on other planets.[15]
The possibilities of transport of germs through space.

**PANEL II: The Evolution of Life.[16]**

The biologist's meaning of "life."
The self-replicating and self-varying properties of DNA.
The Lamarckian and vitalistic-orthogenetic theories of evolution.
The evolution of sex [17, 18].
The study and analysis of the course of biological evolution as shown in fossils and as deducible from the data of taxonomy, comparative anatomy, ecology, and other sciences, etc.
The integration of diversification, transformation, and stabilizations into the process we called biological evolution.[19]
The formulation of general rules and the the study of long-term trends operating in evolution.

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[13] There were many references throughout the discussion of this and related questions to the work of Stanley L. Miller (and Harold Urey) in the synthesis of amino acids under possible primitive earth conditions. Dr. Miller synthesized amino acids by sending electrical discharges through atmospheres consisting of methane, ammonia, hydrogen, and water. (See *Science*, 1953, *117:* 528; *Journal of the American Chemical Society*, 1955, *77*:2351; *Science*, 1959, 130:245.)

[14] In his summary, Shapley said, "I think the answer is no—too much oxygen, too many bacteria . . . Can it occur in a test tube? The vote was yes . . ." The panelists' estimates for the length of time it will take to create life in a test tube, ranged from an upper limit of 1000 years to the lower limit offered by Panelist Muller who said, "I think I am going to shock you if you think you are optimists, because my answer is that those who go along with me in defining life as I do, will admit that the most primitive forms of life which deserve to be called living have already been made in the test tube."

[15] Panelist Darwin was asked to comment on the probability of life existing on other planets. Using Chairman Harlow Shapley's estimate that there are probably in the neighborhood of $10^{20}$ stars likely to have planets, Darwin answered, "My calculations tell me that the probability of this being the only place where there is any life at all . . . is that though you have spun a coin sixty times, it came heads every single time." After some discussions, Shapley commented, "This is all speculation, but I have to call to your attention that the place we have found life—in fact, practice it—is on just an ordinary planet around an ordinary star, a run-of-the-mill star, that is at the edge of one galaxy that has at least 100,000 million other stars, and that galaxy is one of billions. Therefore, it is asking too much to think that this is that one place. I believe you would get heads once or twice in your sixty throws, all right."

[16] In his introduction to Panel II, Chairman Huxley said, "As we saw yesterday, life appears to depend on these self-replicating and self-varying or mutating organic macromolecular strings of DNA, and in all organisms except a few viruses, so-called genetic and evolutionary information is carried by DNA organized into chromosomes in combination with protein. That is the basis of evolution."

[17] In discussing the role of sex in generating a large number of gene combinations and a continual shuffling of genes, Panelist G. Ledyard Stebbins posed the question, "Is sex necessary?" To which Panelist Dobzhansky replied, "My answer is that it is at least desirable." To demonstrate the amount of variation generated by this process, Panelist Wright then made several calculations to show the huge number of combinations produced by relatively small numbers of gene loci each with just a few alternatives or alleles.

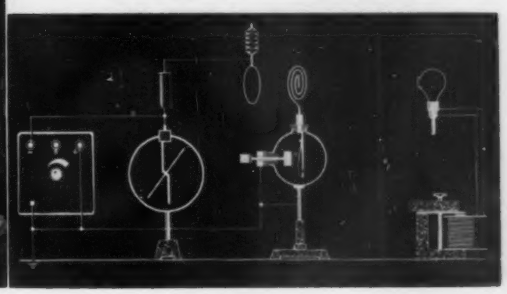
[18] During the discussion of this topic, Panelist Ernst Mayr made the following very significant statement about the old belief that a gene controls a character. "Genes do nothing of the sort, particularly in higher organisms. The gene produces some kind of a gene product by itself, an enzyme or some kind of protein that we do not know about, and that is eventually fed into the total developmental stream. It is part of the total genetic pattern . . . and exaggerated statements have been made that every gene contributes to every character of the organism, and that every character of the organism is in part shaped by every gene.

"Therefore, let us keep in mind that a gene, for instance, which does such an unimportant thing as, let us say, controlling a slight matter of pigment pattern on the outside scale—that the very same gene may control longevity, aggressiveness, heat tolerance, all sorts of things. This is one of the most important findings of physiological genetics, and has more far-reaching effects on the interpretation of evolution. Therefore, let us never go back to the old concept that a gene controls a character."

[19] At this point in the discussion, Panelist A. J. Nicholson reported on a fascinating case of natural selection that took place before his eyes as he was performing an experiment in population dynamics with the Australian blowfly.







The recent development of a "synthetic" theory of evolution linking the findings of many separate disciplines.

**PANEL III: Man as an Organism.**

The status of man in the biological world.
The course of human evolution.[20, 21, 22]
The factors of human evolution.

**PANEL IV: The Evolution of the Mind.**

The influence of Darwin on the behavioral sciences.[23]
The evolution of the mind and of behavior studied as any other organic function.[24, 25, 26]
Human and sub-humans compared as to mind and behavior.
The relation of culture and the evolution of the mind.
The supplementing of genetic evolution by cultural evolution with the advent of civilization.[27, 28]

**PANEL V: Social and Cultural Evolution.**

The unique ability of human beings to produce culture.[29]

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[20] Panelist Bates brought attention to Raymond A. Dart's *Adventures with the Missing Link*, Harper and Brothers, New York. 1959, and to Dr. Leakey's forthcoming book that will describe his discovery of *Zinjanthropus boisei*.

[21] The response to the question, "Is *Homo sapiens* showing evolutionary traits?" was affirmative. The following were cited as examples: Increase in height, loss of hair, loss of wisdom teeth, loss of little toe, rounder head, and more sunken face.

[22] Panelist Rensch said, in discussing this topic, that man's somatic future is unpredictable.

[23] In responding to a question on the extent to which computers think, Chairman Gerard said that he was reminded of the following story. "A very fancy, new, high level electronic computer had been built that could do all sorts of things, and its creator fed into it a great deal of information about man's knowledge and behavior and all sorts of other things, and deposited the question, 'What is the level of human thought?' And the electronic gadget swirled and finally out came some typing and a card fell out of the machine, and it said, 'That reminds me of a story.' "

[24] In discussing this question, Panelist Tinbergen said, "We do know several animals that do use tools in the fullest sense of the word. One example is the Galapagos finch that lives rather like a woodpecker, but instead of having developed the woodpecker's bill it uses the spine of a cactus and probes in cracks and really gets at insects in that way. That is the use of a tool in the fullest sense of the word. All the individuals of the population, as far as is known, do that. Unfortunately, we don't know how it developed in ontogeny, but I think we can make a pretty good guess that this is not learned, although this is a guess and has not been analyzed.

"Another example is the case of the sea otter which carries a stone on its tummy, and when it has got hold of a mussel, it will float on the waves, and hammer the mussel against the stone, and crack the mussel in that way. That, I think, is the definition of the use of a tool. Again, the whole population does it, and again we don't know whether they learn it or not."

In a later panel discussion, Huxley said that it was his opinion that this type of behavior was determined genetically.

[25] In response to the Chairman's question, "Can you think of any example in animals where you can clearly see invention, sanctions transmission of knowledge . . . ?" Tinbergen replied, "As many of you may know, in Britain the titmice have developed a habit of opening milk bottles that are dropped at the front door in a hurry by the milkman, and which have been standing out for about two hours. From a study by Fisher on the spread of this act through Britain, we learn that this has arisen in many different places in Britain, and then, from that, it must have spread through the population, probably through the titmice of the same generation or another.

"There is no doubt that this is an example where a bird has done a new thing; not of one individual in a population, but of a number of them, and that all of them have acted, in fact, as teachers . . . and this thing is now so widespread that most doors have a stone in front of them which is then put on top of the bottle of milk.

"This is a very unique thing. We know of very few examples of this . . ."

[26] In this discussion Panelist Critchley made the following interesting statement. "It seems to me that one of the principal gaps in our understanding of this smooth, orderly progression between the simple and highest representatives of the primates and the lowest representatives of *Homo sapiens* is to explain the abrupt introduction of language; because no matter how vocal an animal is, or how rich its knowledge of sounds, it cannot, strictly speaking, be spoken of as being endowed . . . with either speech or with language. At the very most, we can use the term, 'animal communication.' At the present there seems to be no real connection between animal communication and human speech or language."

[27] Panelist Critchey made the following concluding remarks: "My long-term prophecy is that in the remote future, the inhabitants of the earth will possibly use some form of communication other than words, other than linguistic systems; or else if they do not, they will have to use a vastly improved linguistic system because at the present time words are not enough."

[28] Panelist Von Muralt made the following concluding remarks: "I think that the situation of the neurologists is a bit the same as that of the astronomers. We are beginning to understand a little something about the functioning of one single motor unit, or of one single nerve cell. And the more we learn about it, the more we see that we are just at the beginning of understanding it.

"If we now think that in one gram of brain substance there are various millions of such cells interrelated, I think the only attitude which we can have toward the future is one of pessimistic courage."

[29] The working agenda for this panel included the following statement: "In man, biological evolution through gene shuffling, selection, and mutation can go on simultaneously with cultural evolution, and they are both operative. But cultural evolution has become much the more effective and dominant. The time seems past when biological evolution, in any single species other than man, or in all of them combined, could rival or surpass man's cultural evolution—the opposite seems already to be true."

- The independence of cultural evolution in *Homo sapiens* of gene differences between human subgroups or races.
- Major breakthroughs in human cultural evolution.[30]
- Why most anthropologists and students of culture are less concerned with adaptation and its relentless flow than are biologists.
- Culture history as a counterpart in anthropology and the social sciences to genetic evolutionary science.
- A greater awareness of evolution and of the future as well as the past.[31]

The five panel discussions formed the nucleus of the Darwin Centennial Celebration. However, the Celebration was made even more stimulating and enjoyable by other events. One of these was a delightful, original musical play on the life of Darwin called, *Time Will Tell*. Dr. L. S. B. Leakey gave an illustrated lecture entitled, 'The Origin of the Genus *Homo*" in which he reported his discovery of *Zinjanthropus boisei*, called by Leakey the "first unquestionable man." Sir Charles Galton Darwin, a grandson of the evolutionist, gave another illustrated lecture on "Darwin the Traveler." A feature of the Celebration was a special institute on Darwinism for high school biology teachers.

During the Celebration, the Federated Theological Faculty of The University of Chicago held an Institute on Science and Theology. The institute included lectures on the philosophical and theological implications of the theory of evolution, and a panel discussion to examine the relation of science and religion.

One of the highlights of the entire session was an address, "The Evolutionary Vision," by Sir Julian Huxley at a special convocation.

We can find no better way of bringing this account to a close than by calling the attention of all teachers, and particularly science teachers, to a paragraph in Sir Julian's address which expresses what education should help man to attain.

> The important ends of man's life include the creation and enjoyment of beauty, both natural and man-made; increased comprehension and a more assured sense of significance; the preservation of all sources of pure wonder and delight, like fine scenery, wild animals in freedom, or unspoiled nature; the attainment of inner peace and harmony; the feeling of active participation in embracing and enduring projects, including the cosmic project of evolution. It is through such things that individuals attain greater fulfillment.[32]

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[30] The major breakthroughs recognized by the panel are the following:

1. Food production, beginning gradually about 7000 B.C.
2. A syndrome centering around 3000 B.C. in which writing, metallurgy, urbanization, and political structures were first evolved.
3. The doctrinal and institutional organization of religions from about 600 B.C.
4. A grade of civilization characterized by rapid and progressive development of science, technology, invention, industry, and wealth, beginning about 1600 A.D.

[31] Perhaps the most provocative of the statements made at the Celebration were these of Panelist Muller to this point. Muller outlined a program for the guidance of human evolution. Muller feels that individuals must recognize their responsibility "not only for the education and living conditions, but also for the genetic endowment, of the generations succeeding them." Man's attitude toward reproduction must be "more rational and more socially-directed." To achieve this end, Muller said, "some long entrenched attitudes, especially the feelings of proprietary rights and prerogatives about one's own germinal material, supported by misplaced egotism, will have to yield to some extent." Foster pregnancy, made possible through the techniques of artificial insemination, would be welcomed under this "new morality." This trend would be promoted as our techniques were improved to allow for the transfer, maintenance, testing, selection, and manipulation of both male and female germ cells or potential germ cells. This would make possible the adoption of children before fertilization ("pre-adoption"). These reproductive cells could have been derived from persons dead for many years. Banks of deep-frozen reproductive cells, possibly in culture, could be maintained. We could thus store and use the best genetic material of all mankind—the genetic endowments of individuals such as Lincoln, da Vinci, and Shakespeare.

Muller also described a special kind of parthenogenesis which would make the nature of progeny even more predictable. The offspring obtaining his hereditary material entirely from one individual would be a genetic twin of that individual. This could be accomplished, Muller explained, by extracting the nucleus from a fertilized human egg, and inserting in its place another nucleus obtained from a cell of a pre-existing individual, specially chosen for outstanding traits or potentialities. It would thus be possible to bring back to life outstanding persons long since dead, a physical immortality. Experiments of this kind have succeeded in creating parthenogenetic frogs. Muller feels that extending this method to mammalian and eventually to human fertilized eggs does not seem at all farfetched.

[32] The full text of Sir Julian's convocation address and of the proceedings of the five panel discussions will be published in 1960 by The University of Chicago Press as *Issues in Evolution*, Volume III of *Evolution After Darwin*, The University of Chicago Centennial.

# AO Reports on Teaching with the Microscope

## Osmotic Action and Reaction or Social Life Among the Molecules

Here are two very short experiments that could be incorporated in a single class session. Both provide a brief, though enlightening introduction to the study of osmosis.

The first experiment by Dr. Frank E. Wolf presents the subject in its "growing phase". Mr. John A. Burns contributed the second experiment which is concerned with the "net movement" of osmosis. Both give an excellent visual demonstration of circulation and activity that takes place when a solvent and a solution tend to equalize their concentrations.

### EXPERIMENT

Simulated Life Processes

By *Dr. Frank E. Wolf*
*Professor of Biology*
*State Teachers College*
*Fitchburgh, Mass.*

Early in some biology courses, it is customary to make comparisons between living and nonliving things. Sometimes a chemical garden demonstration is used to motivate an exploration into these differences. The garden meets some of the criteria of both categories: the "plants" apparently grow, reproduce, move, etc. All of these life processes are in some way dependent upon osmosis, for which the chemical garden is also an excellent demonstration. The following demonstration goes one step further. With the aid of the AO Spencer Cycloptic Stereoscopic Microscope, the process of *circulation* may be observed in a chemical garden "plant".

**MATERIALS AND PREPARATION:**

AO Spencer Cycloptic Stereoscopic Microscope, small containers such as one dram screw top vials or microtechnique test tubes, water glass (sodium silicate), ferric chloride and/or nitrates of cobalt, nickel, manganese, iron, lead, and copper; sulfates of copper, aluminum, iron, and nickel; chlorides of cobalt, manganese, and copper.

Fig. 1

Dilute the water glass one part to three parts of water for a relatively slow reaction; or one to one for a faster reaction; forty percent is probably the most convenient, all-around strength.

**PROCEDURE:**

Fill a small container with the diluted water glass and add a small lump of ferric chloride or other compound listed. Observe under the stereoscopic microscope (Figure 1).

**OBJECTIVES:**

1. Observe the membrane-like sacs "growing" from the ferric chloride. Note that as the sac forms a tube, "cells" appear.
2. Focus on the inside of a growing tube and note the process of "circulation" taking place (Figure 2).

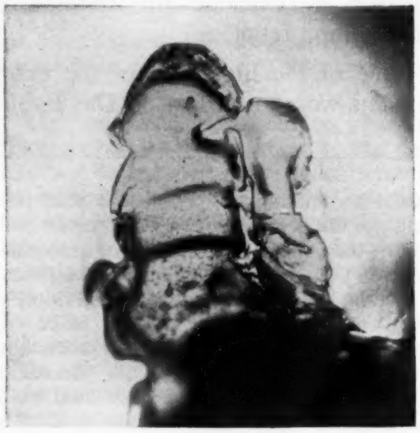


Fig. 2

NOTE: The stronger water glass solutions cause faster reactions with better views of circulation, but less well-defined cells. The weaker solutions are recommended for less experienced viewers because the reaction is slower and easier to follow. In either case, the demonstration proves exciting and quite interesting.

### EXPERIMENT

To observe effects of molecular action included in study of osmosis.

By: *John A. Burns*
*Vestal Central School*
*Vestal, N. Y.*

**MATERIALS AND PREPARATION:**

Two AO Spencer No. 66 Student Microscopes, two microscope slides with cover slips, water, molasses, carmine red dye, and two probes or needles.

**PROCEDURE:**

Prepare two slides; the first a temporary mount of carmine dye in water, the second a temporary mount of the dye in molasses. Both may be easily made by dropping 2-3 drops of water (or molasses) on slide, then transferring a few grains of the carmine dye on the end of a needle into the water (or molasses) and stirring. Add cover slip, place each slide under high power (43X) of microscope (Figure 3), and focus until vibration of tiny dye particles is observed.

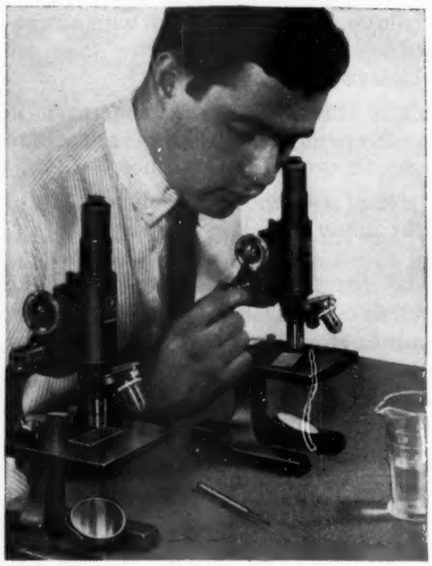


Fig. 3

**OBJECTIVES:**

1. Look for vibrating movement of dye particles in water slide. This "jiggling" of minute particles is called Brownian Movement, and is caused by rapid-moving water molecules hitting against visible dye particles in random fashion. Even though the water molecules can't be seen, their presence is revealed by their effect on the dancing dye particles.
2. Now look for slower, more sluggish vibration of dye particles in molasses slide. Large, slow-moving sugar molecules bounce the dye particles far less vigorously.

**APPLICATIONS:**

Students can visualize relative size of water and sugar molecules by observing their activity on dye particles. The small water molecules are active, move rapidly and therefore can be imagined as minute. By comparison the sugar molecules can be visualized as huge, due to their sluggish effect on the dye particles.

By combining the ideas of molecular sizes and activities with the concept of membrane permeability, an understanding of osmosis evolves. Students can then understand basic reasons why the standard carrot, potato, or beef bladder osmometer operate as they do, and thus can see how absorption can occur in plants, animals, and in the human body.

# A Blood Research Project With Gifted Students

**By ETHELREDA LAUGHLIN**

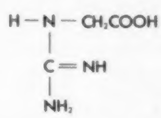
Science Teacher, Cleveland Heights High School, Cleveland, Ohio

SPECIAL projects are often suggested as means of interesting and stimulating the gifted student. Since accumulation of knowledge is also a goal in the secondary school, why not combine these two objectives in a worthwhile research project?

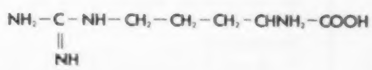
**Start with a question.** There are many unanswered ones in science. Ours was the teasing question, "What are the components of the rest (residual or undetermined) nitrogen of the blood in kidney disease? Every textbook discussing chemical components of the blood lists a value of 25 to 35 mg per 100 ml for the total nonprotein nitrogen of a healthy adult. Of this, 10 to 15 mg is contributed by urea nitrogen, 2 to 3.5 mg by uric acid nitrogen, and 1 to 2 mg by creatinine nitrogen. The remaining 5 to 18 mg is simply titled "undetermined nitrogen." In kidney disease this value is even higher and may make up 45 per cent of the total nonprotein nitrogen fraction.

**Formulate a hypothesis.** Try to find a probable answer and proceed on the basis that it is correct until proven otherwise. We began with the hypothesis that, at least in cases of kidney disease, a large part of the rest nitrogen of the blood is composed of guanidinium compounds. Five were chosen for our study.

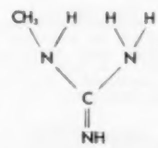
Guanidinoacetic acid



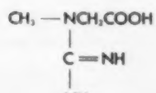
Arginine



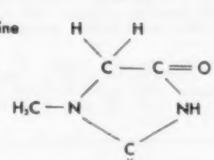
Methyl guanidine



Creatine



Creatinine



One, creatinine, is well known but was necessary for obtaining creatine values.

**Choose the gifted students.** This was very difficult in our large high school. The four of us teaching chemistry made lists of our "A" students; then the guidance department was brought in. The standard for "gifted" was arbitrarily set as follows: IQ above 130, Lee Algebraic Aptitude Test score above 120, and reading level (California test) above 12.0.

Since working space for projects is very limited at the school, only six were chosen. This number was later increased to eight. Scheduling the boys was difficult. The brightest in the school are also in many activities and carry the heaviest class programs. Some could be scheduled for only three class periods per week, but all agreed to stay after school and come in on Saturday mornings when necessary.

**Plan the program.** First, techniques had to be learned for use of the analytical balance and the centrifuge. Pipetting had to be mastered and care of glassware learned. Since results are meaningless unless techniques are mastered, many weeks were spent just practicing.

Next, standard curves had to be drawn for each of the five compounds studied so that colorimeter readings obtained from blood could be con-

**NOTE: This "Here's How I Do It" chemistry project was presented by the author at the 1959 Atlantic City Convention of NSTA. Initially, a grant was awarded under the Future Scientists of America Foundation program for this on-the-job research project.**

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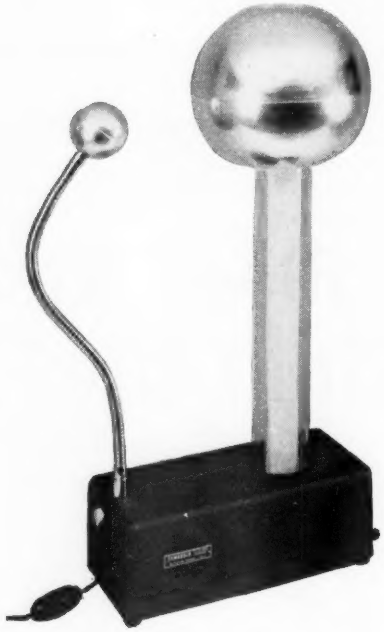

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The only part subject to deterioration is the charge-carrying belt, which is readily replaceable.

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**CHARGE-CARRYING BELT** To the terminal, charges are conveyed by an endless band of pure, live latex—a CamboscO development which has none of the shortcomings inherent in a belt with an overlap joint.

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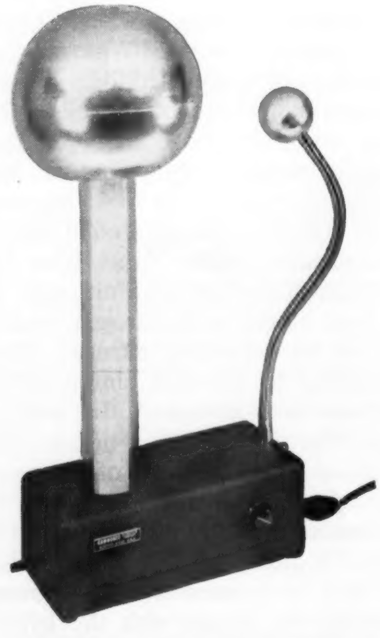
**BASE...AND DRIVING MECHANISM** Stability is assured by the massive, cast metal base—where deep sockets are provided for the flexible shaft which carries the discharge ball, and for the lucite cylinder which supports, and insulates, the discharge terminal.

The flat, top surface of the base (electrically speaking), represents the ground plane. Actual connection to ground is made through a conveniently located Jack-in-Head Binding Post. The base of the Genatron encloses, and electrically shields, the entire driving mechanism.

**PRINCIPAL DIMENSIONS** The overall height of the GENATRON is 31 in. Diameters of Discharge Ball and Terminal are respectively, 3 in. and 10 in. The base measures 5¼ x 7 x 14 in.



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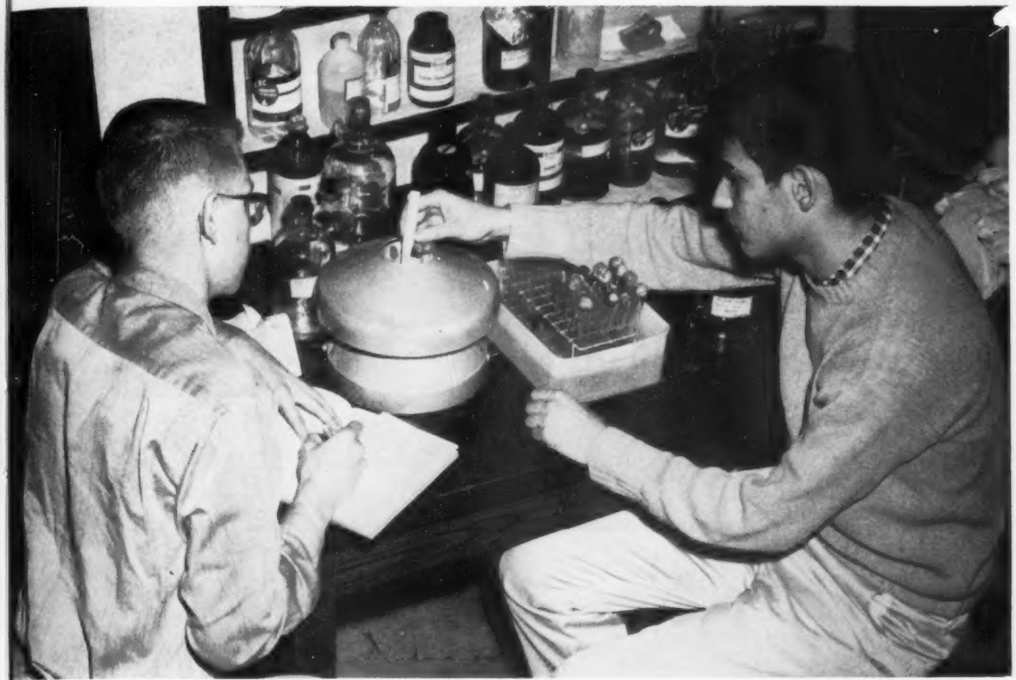


RONNIE SHERMAN, SCHOOL PHOTOGRAPHER

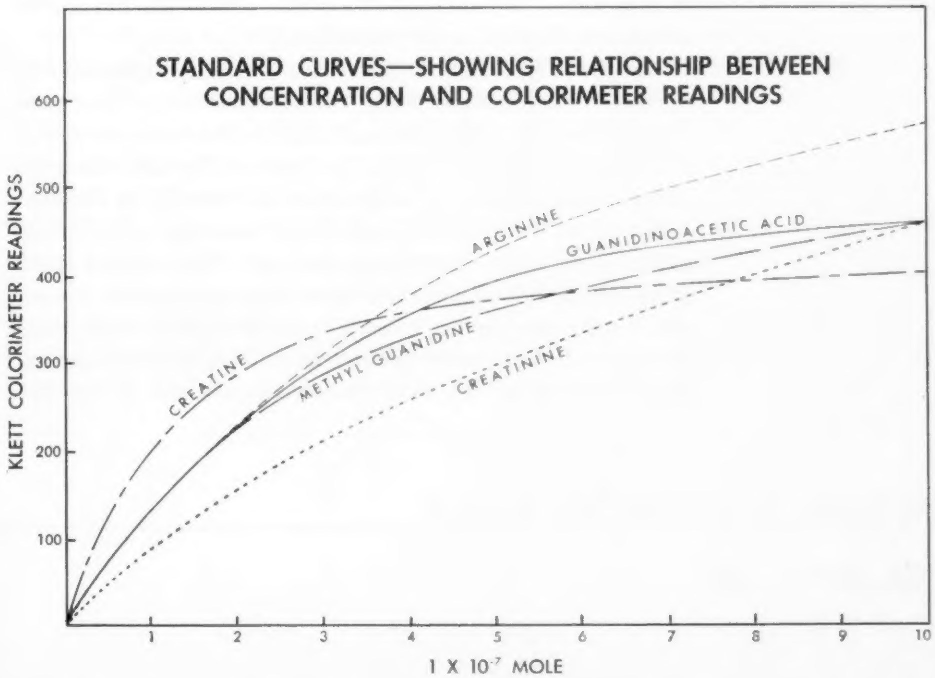
Ronald Kaye, right, starts to centrifuge tubes after adding protein precipitating reagents to blood. Homer Guffin records data. (Senior class, Cleveland Heights High School.)

verted directly to milligrams per 100 ml of blood.

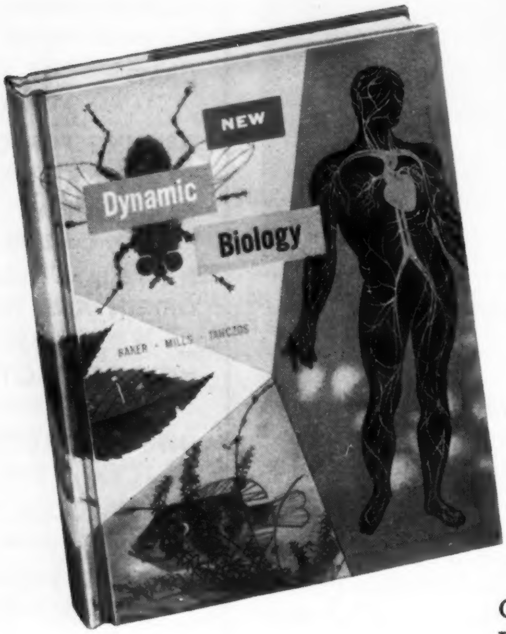
We used a modification of the Sakaguchi color reaction described by Van Pilsum *et al.* (*Journal of Biological Chemistry,* 222:225, 1956). The procedure had to be changed somewhat to utilize the equipment we had. Instead of a spectrophotometer we used a Klett colorimeter, and so required larger volumes. Since several of the procedures could not be carried on one step following another, time intervals had to be varied to fit into our school day and individual student's schedule. Our readings were made at 520 m$\mu$ instead of at 515 m$\mu$ suggested by Van Pilsum. The green filter provided us with a wave length closest to the ideal.

Standard solutions were made of

FIGURE 1.



# NEW 1959 Dynamic Biology




**by**

**Arthur O. Baker**

**Lewis H. Mills**

**Julian Tanczos, Jr.**

Over the years, you have probably relied on DYNAMIC BIOLOGY and DYNAMIC BIOLOGY TODAY to do the most effective teaching job for you. Today, NEW DYNAMIC BIOLOGY becomes the textbook for tomorrow. Make no mistake about it; it is a new text written by three of America's outstanding scientists whose distinguished talents are known across the nation.

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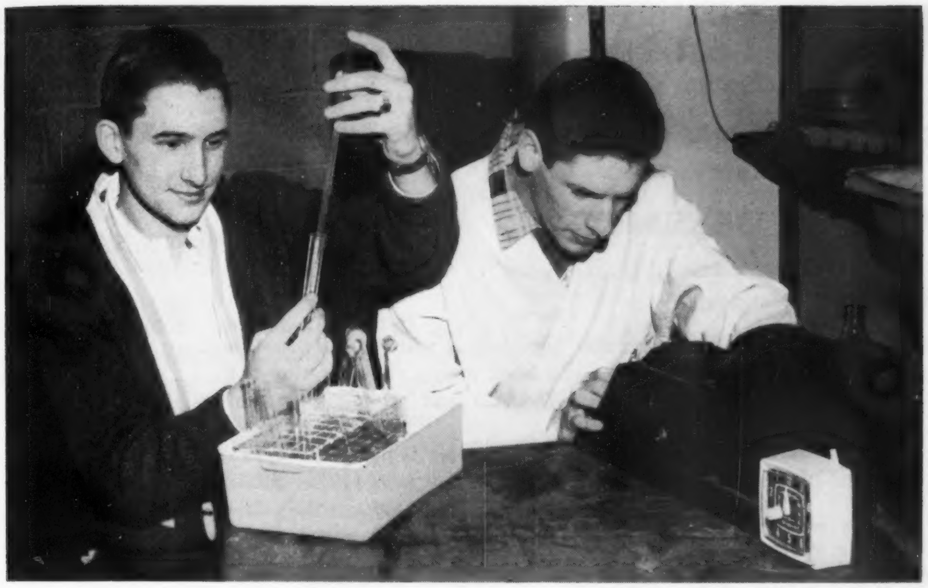

RONNIE SHERMAN, SCHOOL PHOTOGRAPHER

Barry Bassett and Steve Ellis, seniors. Barry adds reagents to tubes in ice bath while Steve makes colorimeter readings.

each nitrogen compound to contain $X_1$ $0.1\mu$ mole/0.1 ml, so that one milliliter of solution was equivalent to $1 \times 10^{-7}$ moles. (Figure 1.)

The Sakaguchi color reaction can be performed directly for guanidinoacetic acid, arginine, and methyl guanidine. The procedure used is as follows:

1. The colorimeter tubes containing solutions to be measured are chilled in an ice bath.
2. 1.0 ml of alkaline-naphthol-thymine mixture is pipetted into the tubes.
3. After mixing, 0.4 ml of NaClO solution is added with immediate mixing.
4. Exactly one minute later, 0.4 ml of $Na_2S_2O_3$ solution is added with immediate mixing.
5. The tubes are read at 520 m$\mu$.

Creatinine, to be read colorimetrically by this procedure, must first be converted to methylguanidine. This is accomplished as follows:

**Tube 1 (Reagent tube)**

1. Add 2 drops of o-nitrobenzaldehyde.
2. And 0.4 ml of 1.25 N NaOH.
3. Mix and let stand 20 minutes.
4. Add 1 ml phosphate buffer-$H_2SO_4$ mixture and mix.
5. Heat in boiling water bath for 10 minutes.

Robert Lewis uses the analytical balance.

RONNIE SHERMAN, SCHOOL PHOTOGRAPHER

6. Cool.
7. Proceed with color reaction.

**Tube 2 (Control tube)**

1. Add 1.0 ml phosphate buffer-$H_2SO_4$ mixture.
2. Add 0.4 ml of 1.25 N NaOH.
3. Proceed with color reaction. Add 2 drops o-nitrobenzaldehyde just before addition of the NaClO solution.

Creatine must first be converted to creatinine and then to methylguanidine before the color reaction may be performed.

**Tube 1 (Reagent tube)**

1. 1.0 ml citrate buffer added.
2. Tube covered with glass marble and heated 2 hours in boiling water bath.
3. Cool to room temperature.
4. Add 0.4 ml of 1.66 N NaOH.
5. Creatinine procedure follows.

**Tube 2 (Control tube)**

1. Add 1 ml of 0.15 citrate buffer, pH 2.2.
2. Add 0.4 ml of 1.66 N NaOH.
3. Add 1.0 ml phosphate buffer-$H_2SO_4$ mixture.
4. Tube is ready for color development.

After standard curves were drawn for each of the compounds, we planned to go ahead with the same determinations on blood samples. Four hospitals in the Cleveland area generously agreed to send us blood remaining from their work. We had hoped initially to use hospital values for nonprotein nitrogenous blood constituents. We found, however, that only blood urea nitrogens are done routinely and that we would have to do the determinations ourselves. The quantities of blood aliquots were often so low that we had to pool two and more and even the BUN readings furnished us could not be used. We added to our procedures NPN determinations (Koch and McMeekin, *Journal of American Chemical Society,* 46:2066, 1924), urea nitrogen (method of Karr, *Journal of Laboratory & Clinical Medicine,* 9:329, 1924), and uric acid nitrogen (method of Folin, *Journal of Biological Chemistry,* 101:111, 1933 and 106:311, 1934).

**Analyze the results.** To date we have reports on only ten pooled blood samples of patients with nephritis and these are not all complete.

From the readings tabulated so far we have to conclude that there is little elevation, if any, of guanidinium compounds in the blood in kidney disease.

The following represents averages of the pooled samples:

| | | |
|---|---|---|
| 1. Total nonprotein nitrogen | 81.66 | mg/100 ml blood |
| 2. Urea nitrogen | 46.33 | |
| Uric acid nitrogen | 26.74 | 78.07 mg total |
| Creatinine nitrogen | 5.00 | |
| 3. Undetermined nitrogen | 3.59 | (difference) 1 minus 2 |
| 4. Arginine nitrogen | 0.34 | |
| Methyl guanidine N | 0.55 | 0.98 mg |
| Guanidinoacetic acid N | 0.09 | |

The latter three guanidinium compounds make up 7 per cent of the total nonprotein nitrogen and 24.5 per cent of the undetermined nitrogen.

**Conclusions.** Many more results are needed before any conclusions can be drawn. If the guanidinium compounds make up 25 per cent of the rest nitrogen, we need another hypothesis to start looking for the yet undetermined 75 per cent. The problem of determining the constituents of the rest nitrogen of the blood is far from solved. The value in the project, aside from finding results, is the example of encouraging cooperation between students in working as a team on a research problem.


# Research on the Teaching of Elementary School Science

By PAUL C. BURNS

Assistant Professor, School of Education, The University of Kansas, Lawrence, Kansas

IN this article a brief review is presented of several studies at the elementary science level which deal with instructional methods and procedures. It is hoped that many of our readers will be able to discover applications of some of the findings to their own teaching techniques.

A study was made of the effectiveness of two methods of teaching science in fourth, fifth, and sixth grades by Stefaniah (14) to determine whether teachers taught by the lecture method did a more effective job than teachers exposed to the individual laboratory method. Experimental and control groups of in-service teachers participated with the instructions centered around a list of forty principles of science. Pupils were pre- and post-tested to determine gains or losses in interests and content. Results seemed to favor teaching of those instructed by individual laboratory method, although the difference was not marked.

Baker (1) studied the reactions of pupils to science experiments by conducting a series of experiments in grades three through six. No explanation or comment was given during the experiment, but following it the children were asked, "What happened and why?" It was found that many pupils could interpret and generalize without help of the teacher.

An early study reported by Beauchamp (2) sought to determine the relative efficiencies of two different methods of study, semi-directed study and directed study, of science materials. He came to the general conclusion:

> Specific training in finding the central thought of a paragraph, determining the question one must be able to answer in order to obtain adequate understanding of a topic, and reading an entire block of material through for its general plan, results in a more thorough comprehension of subject matter than undirected study on the same material.

Robertson (12) carried out an experiment to compare the relative effectiveness of a "guidance-outline" method and a "developmental-discussion" method. He selected six units of work and then taught one group by the developmental-discussion method in which discussion was based on the children's interest. He taught the other group by guidance. With guidance, the children worked individually receiving aid when needed. Groups were equated on basis of reading ability and previous science achievement, and other necessary factors were held constant. In addition, the groups rotated during the course of the experiment. The groups were tested for immediate and delayed recall; the developmental-discussion group did slightly better on both tests.

Haupt (8) reported the results of an experimental study in which a philosophy of science education, as set forth in the Thirty-first Yearbook of the National Society for the Study of Education, was applied. He selected one objective of instruction (consideration of energy relationships between sun and green plants) and used it as a basis of teaching. He equated and pre-tested groups of children in grades one through six, instructing them in respect to the objectives. Then he re-tested them. He concluded that the same instructional objective could be used at all grade levels; that the same mental activities occur at all levels, differing only in complexity; and that children generalize at all levels.

Should science be integrated with other elementary school subjects? Mallinson (9) made an analysis of elementary science and geography books to discover what similarities existed in the two subject matter areas. He found that similarity did exist in the areas of agriculture, air, earth as a planet, forest, fishing, and mining. He felt that where similarity exists, the two subjects could be properly integrated.

Integration of science with mathematics at the seventh- and eighth-grade levels was investigated by Gorman (6). He selected a science and mathematics text and from them determined common topics of study. For the experimental group, he constructed a workbook consisting of common problems and activities. The control group studied science and mathematics independently but covered the same topics. The groups were equated and the results of the study, based on achievement test scores, indicated no appreciable difference in efficiency of the two methods of instruction.

How effective are various multisensory aids? Greene (7) reported a comparative study of efficiency of dramatic and non-dramatic methods in teaching science to fifth-grade children. In the experiment two plays were used as teaching procedures, teacher-written ones and pupil-written ones. The control groups used their usual procedures. He concluded:

> Children learn factual information only slightly, if any, more rapidly when taught by dramatic rather than by a non-dramatic method, but the following desirable learnings developed more strongly: speech arts; poise; group organization; social interplay.

Silano (13) conducted an experiment to test results of using drawings as learning aids. He selected two groups of seventh graders and tested them and determined their knowledge of air-

planes. One group was given instruction about planes in a traditional manner; the other group was given usual instruction and in addition was taught to draw a well-proportioned airplane. The two groups were again tested and the experimental group missed fewer questions. One fault of this study, however, was the failure to equate groups at the beginning of the study.

The value of radio broadcasts has been studied. Carpenter (4) reported two studies. In the first he described the results of an experiment in teaching science by radio in the Rochester School of the Air. The radio broadcast followed a prescribed course of study, twice per week for one semester, thirty-minutes in length, followed by twenty minutes of class discussion. Results of final achievement tests administered to "radio" class and "traditional" class indicated that "radio" class did only as well as "traditional" class.

On the other hand, Brewer (3) worked with experimental and control groups in New York City in testing radio as an aid to instruction in elementary science. He used five broadcasts on certain concepts of nature. With elaborate statistical techniques he secured the results that radio programs do serve as definite stimulus to further activities. Miles (11) came to the same conclusion when the broadcast had been planned carefully and taught specifically as in the experiment designs procedure.

Recorded science lessons were reported by Carpenter (5). Forty science lessons, ten minutes in length, were recorded. These were heard by approximately 11,000 children. A science interest test was given at the beginning and end as well as a science achievement test. From the results, records appeared functional in increasing factual knowledge, skills, and interests.

Martin (10) carried on a study to discover relationships of "community resources and use of the tape recorder." The tape recorder was a very satisfacory and successful aid in teaching, he concluded from his study.

What summary, in the form of trends and conclusions, may be made at this time relative to research and its implication in the elementary school science area?

1. There appears to be of recent date an increased proportion of learning studies as opposed to curricular studies in the field of elementary science.

2. Since the early studies there has been marked progress in the refinement of statistical procedure used in the studies.

3. Studies would appear to indicate that efficient teaching of science demands definitely organized experiences, rather than reliance on incidental methods.

4. Most studies favor organization of science around cores of subject matter, supplementing instruction by means of demonstration, discussion, drawing, and experiments. Data from several studies would appear to strengthen the case for a greater laboratory approach at the elementary level. Availability of material no doubt has some effect upon the type of instruction typically used.

5. As yet there appears to be no final experimental evidence to indicate the value of integration of science with other elementary subjects.

6. Research seems to indicate that multi-sensory devices are helpful in developing interest and possibly toward increasing pupil factual knowledge of science. An additional value is their help to elementary teachers who may lack subject matter background in the field of science.

7. Major emphases in the past few years in elementary science research appear to be in the field of audio-visual aids and other such devices to learn more about teachers' ability to gain pupil interest.

8. There appears to be a great deal of research still needed with respect to teaching of scientific attitudes and problem-solving skills. Although these are accepted as major objectives of science instruction, it would appear that most teaching still centers around dissemination of factual information, even where problem or unit approach is mainly used. Another area that needs investigation is that of proper use of laboratory exercises.

9. No significant advantage of any one method over another has been definitely proven. All methods are valuable if properly used. While some procedures are superior in a given situation, in general, they all have value at one time or another. Selective use of many techniques is probably still the most advantageous procedure for the teacher.

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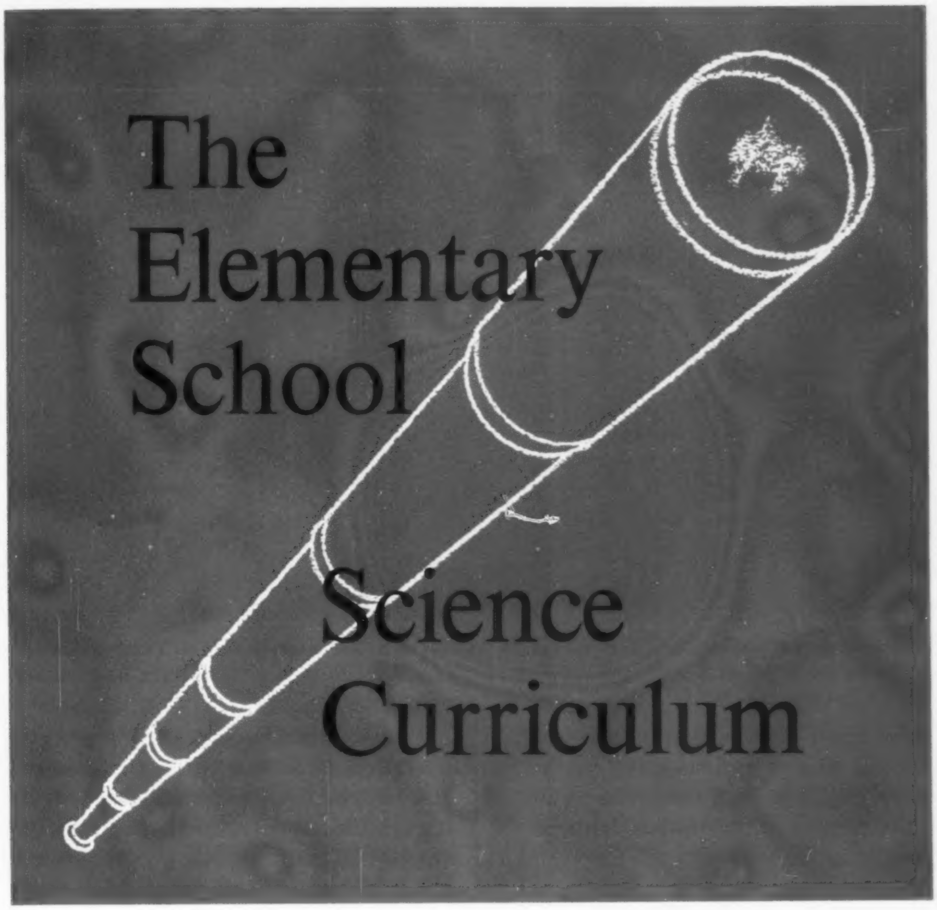
# The Elementary School Science Curriculum



**By J. MYRON ATKIN**

College of Education, University of Illinois, Urbana, Illinois

THE elementary school science curriculum in most American schools today is based on a pioneering study reported by Craig in 1927.[1] The results of this study have served us well for over thirty years. But the inevitable questions must now be asked: Is the curriculum appropriate today? Are basic revisions necessary? Is it satisfactory to retain the essential structure of this curriculum and make only those minor modifications demanded by new science knowledge?

Craig's study was, in part, a reaction to some of the excesses of science teaching dominant during the first quarter of the century. But it was also firmly grounded in an educational viewpoint then crystallizing at Teachers College, Columbia University. The increasing body of knowledge about children, their growth and behavior had certain clear implications for building a new curriculum. The child himself was studied intensively, and the results of these studies pointed toward new instructional approaches in school. Education for living: Start at the level of the child and build a curriculum considering his psychological and biological stage of development. What do children want to know? What do they need to know to comprehend the world that impinges on them daily? How should cultural factors influence the curriculum? These are some of the issues that were beginning to demand attention from educators.

To construct his course of study, Craig identified four criteria for building a science program. The program should (1) "greatly influence the thought reaction of the individual," (2) reflect content which has "modified thinking in many fields," (3) help to establish "health, economy, and safety in private and public life," and (4) reflect content "essential to the interpretation of the natural phenomena which commonly challenge children." By identifying these criteria, Craig helped to give a rational structure to a science program at the elementary school level, a structure that was loose at best prior to 1927.

Craig used three primary sources to construct the science curriculum: the interests of children as reflected by their questions, the opinions of laymen, and certain standard college science texts. The result was a course of study that stressed heavily the influence of science on daily life. Those phenomena which seemed to loom large in the lives of youngsters and adults and which were rooted in science as identified in college texts of the period constituted the curriculum. Topics included electric motors, circuits, description of certain weather phenomena, rock identification, and the economic uses of plants, among many others. A glance at the Course of Study reveals an attempt to cover a broad range of topics in geology, astronomy, biology, meteorology, physics, and chemistry. Craig placed greatest emphasis on his criteria (3) and (4) in selecting content.

Subsequent investigators have turned considerable attention to Craig's first criterion, that of "greatly influencing the thought reaction of the individual." This attention has taken the form of a plethora of writing about scientific method, critical thinking, and problem-solving ability. While there is considerable agreement in the field today that the improvement of children's thinking is a primary goal of science education, very little effort in the field of education bearing on this subject over the past twenty years may be termed research. Attempts have been made to describe problem solving, scientific method, and critical thinking, but comprehensive research programs to discover how such thinking develops and is nurtured through *formal school subjects* are yet to be reported. There has been no basic change in elementary school science curricula in over the past thirty years.

### Curriculum Revision

What are the implications for the current spurt of activity, all of it sorely needed and much of it brilliant, on

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[1]Gerald S. Craig. *Certain Techniques Used in Developing a Course of Study in Science for the Horace Mann Elementary School.* Bureau of Publications, Teachers College, Columbia University, New York. 1927.


Restructuring the science curriculum to include new content and capture interest requires constant evaluation.

elementary school science programs? First, it can be recognized at the outset that much of the criticism of high school curricula applies to elementary school science programs with equal force. We now cover a large amount of superficial teaching-about-science in the elementary school. The stress is still on applications of science, science in daily living (science in cooking, science in health, science in toys, science in today's refrigerators, etc.). Rarely, very rarely, are children encouraged to probe to some depth in a scientific discipline to appreciate something of its rationale and inner consistency. Rarely are children helped to go beyond the descriptive (nine planets move around the sun; Mars has two natural satellites; shots protect against certain diseases). For most elementary school science teaching, books at the descriptive level are the only books available.

A second weakness in elementary school curricula is one that threatens to weigh down the entire structure. A curriculum in science built on children's interests and the applications of science must grow geometrically in this day and age. Each new technological advance breeds more technological advances. How does one pick from this wealth of achievement that which should be taught to the very young?

Pruning thus becomes a top priority operation in restructuring the elementary school science curriculum. It is impossible to add new content to the already bulging science program without substracting something. New types of immunization, new surgical techniques, new artificial satellites are all events that are beginning to crowd one another off the front page. The teacher who tries to teach this current content in addition to the already prescribed science work in anything but a cursory fashion is lost. Each new development reveals the teacher's own lack of preparation. Each frantic effort to keep pace with technology clutters curriculum content even further. What content can we afford to drop? What are some reasonable criteria for selecting that which we take time to teach?

The underlying viewpoint of the major secondary school curriculum reform movements in evidence today holds that the major criterion to be used in selection of course content should be to choose that subject matter which is fundamental to the discipline as the discipline is viewed by those with its most penetrating grasp. The man to go to in selecting content for high school physics is the man steeped in the subject, the man who knows it deeply *and* broadly; in short, the man recognized by physicists as a productive authority. It is probable that most curriculum reform movements in the field of elementary school science

will have the same flavor. Thus the desired pruning is accomplished initially on the basis of subject matter considerations. On the surface at least applications of science and children's immediate interests assume a minor role in selection of content. As criteria for a pruning operation, the new emphasis seems reasonable. What might it look like in practice?

Take elementary school astronomy as an example. In this field, the writer, together with Professor Stanley P. Wyatt of the University of Illinois Astronomy Department, has been conducting an investigation with youngsters in the intermediate grades designed to effect pruning based initially on subject matter considerations.

An examination of elementary school textbooks and trade books in the field of astronomy currently available to teachers of elementary school children reveals an almost exclusive emphasis on the solar system. However, though the solar system is discussed at length, the stress is placed entirely on its descriptive aspects. Children are taught the number of planets, their relative sizes, their distances from the sun, and the number of moons revolving around each one. There is also some description of what we know about the surface of Venus, Mars, and Jupiter. In most books certain constellations are identified. Eclipses are discussed, and seasonal change is stressed. The youngster is also subjected to considerable information about the distances between various objects in the solar system.

This content for elementary school astronomy may be criticized on several grounds.

1. The child is given virtually no understanding of how scientists have arrived at the factual material presented in the children's books.
2. The child is given virtually no comprehension of the structure of our own galaxy of stars or of the physical universe and its component galaxies.
3. The child learns in only a cursory fashion of some of the forces at work in this physical system.

With regard to point (1) above, people cannot learn the basic ideas in astronomy without an understanding of how we arrive at astronomical knowledge. What types of observation are important to astronomers and why? What are theories? How do scientists build them? Even if children studied the solar system exclusively, they can learn much more about astronomy by tracing some of the historical developments with regard to man's conception of the motion of bodies within this system than by reading the books currently available to them.

With regard to points (2) and (3) above, much more could be done with elementary school children to point up concepts related to gravitation; the nature of matter and radiation; the age, origin, and evolution of the solar system, of stars, and of galaxies. These concepts reflect some of the basic concerns of modern astronomers, yet little attempt has been made to teach these concepts at the elementary school level.

Research is needed to bring elementary school science curricula in consonance with the enormous amount of astronomy that has been learned in the last two or three decades and its major methods and problems today. And in so doing, such research should point out possibilities of how younger children may learn astronomy in depth.

The starting point in this investigation was at the level of the professional astronomer. Wyatt studied the textbooks and trade books currently available to elementary school children in the field of astronomy and outlined several topics that are of vital importance in the discipline but which receive scant attention in the instructional materials for young people. Gravitation, radiation, statistical inference, problems of vast distances and age, problems of origin, and radio astronomy are a few of the neglected modern ideas deserving greater emphasis particularly in the context of the structure of the physical universe as an entity.

With one group in the pilot project, a historical view of the development of man's conception of the solar system was developed. Children were made responsible for devising a view of the solar system based on evidence available to ancient and medieval astronomers. Fourth-grade youngsters showed the ability to conceptualize a scheme of epicycles to describe retrograde motion of the planets. By stressing this topic with the youngsters, the investigators were somewhat successful in the general aim of helping children to realize some of the problems astronomers actually have. In using an inductive approach it is felt that children were helped to see astronomy as a field characterized by problems that challenge the intellect. Further, the youngsters developed a greater appreciation

**In directing a science experiment, how much is the child encouraged to probe deeply into the scientific discipline? Does the teacher influence the thought processes?**

DEARBORN PUBLIC SCHOOLS, MICHIGAN

for the Copernican Revolution when they themselves had to develop a system that accounted for retrograde motion assuming a helicentric view of the solar system.

With other groups of children considerable attention was given to the problem of measuring relatively short distances in space by triangulation. Again, the feeling has been in this project that the measurement of distances in space is a much more important notion than merely knowing the distances that are thus measured.

Another experimental group has been concerned primarily with certain basic physical concepts such as mass, inertia, and momentum.

A high degree of success characterized the initial and spotted efforts to teach this "new" content to elementary school children. Children in grades 4, 5, and 6 can and do learn many of the concepts outlined above. Further, children's interests have been consistently high, and parents report that the youngsters take the science problems home for further discussion. So far, however, the investigators have worked solely with intellectually gifted children, and this writer has been the only teacher working with the children. Several questions arise:

1. Is this basic approach appropriate for all fields of science?
2. Will this approach prove effective with children of average and below average intelligence?
3. Can teachers in the self-contained classroom (who now do the science teaching) handle this content?
4. How does one translate the curriculum reform movements from the experimental and relatively tightly controlled setting to general classroom practice?
5. The most basic question: Is this the content that should be stressed?

No doubt there will be much attention in the next decade to these broad questions. No doubt new fundamental questions will arise that are difficult at present to articulate. But it seems a certainty that funds on an impressive scale will be funneled into elementary school science curriculum reform during the next few years. Partly because of the large sums invested, it is probable that change will be effected at a much more accelerated rate than has been characteristic in the elementary school science field in the past. A faster rate of change demands (1) involvement and/or (2) careful systematic evaluation in the earliest stages of the new projects by those who have been identified professionally with the field of elementary school science and who hold strong views about the aims and objectives of early science learnings.

In keeping with the trend to make articles in educational journals constructive, this writer feels that the curriculum reform as outlined holds considerable hope for building elementary school science programs that improve children's thinking, yet use the exciting vehicle of modern scientific concepts. At its best, such reform results in teaching what is intellectually challenging, flexible, open-ended, and heuristic. The by-products of such curriculum reform movements (cooperation between people in the fields of science and education) seem as promising for continued progress as the published results of the reform movements themselves.

# NEW DEVELOPMENTS IN HIGH SCHOOL SCIENCE TEACHING

**Report of an NSTA Staff Study**

WHAT should be the content of an advanced physics course? How many hours should be allotted for laboratory work in chemistry? What science should be taught in the ninth grade? Suggested answers to these and many other questions are to be found in the National Science Teachers Association's recent publication, *New Developments in High School Science Teaching*. (Price $1.50)

New courses, programs, and administrative procedures from school systems across the country have been described in this 108-page report. In addition, references have been made in it to over one hundred developments and to several major curriculum-planning projects now under way.

This publication is based on a descriptive study of science programs in grades 7-12 in all parts of the United State. It reveals several general trends which cut across subject matter lines.

1. Many new administrative procedures have been established for extending the school program to out-of-school hours and for enlisting the cooperation of college, community, industry, and government groups.
2. The new science courses have greater academic rigor than standard ones.
3. The seminar is a new development for teaching discovery methods and cutting across subject matter lines.
4. Ability grouping is increasing.

Within the framework of these current trends changes can be seen in the various subject matter areas.

In general science there is less reading and talking about science and more of doing it. The amount of laboratory work is increasing and projects are a popular activity. General science courses are being separated from the core program in many schools. Principles of biological and physical science are being stressed in courses designed to lay strong academic foundations for future courses in biology, chemistry, and physics.

Earth-space science is a popular substitute for ninth-grade general science. It combines elements of astronomy, meterorology, and geology in a single course for students of greater than average ability and interest in science.

A majority of the new biology courses are being introduced in the ninth grade, although the tenth grade remains at the level at which the subject is generally given. Biochemical and biophysical aspects of biology are being stressed.

Placing biology in the ninth grade allows for a four-year science sequence. The fourth-year elective might be an advanced course in biology, chemistry, or physics; a specialized course such as microbiology or electronics; or a science seminar.

Physical science courses for academically talented students are also gaining in popularity. Many of these courses combining basic elements of physics and chemistry, are being offered in the tenth grade. There appears to be considerable merit in such courses—greater immediate and delayed retention and greater economy of time. Several patterns of physical science programs are described in *New Developments in High School Science Teaching*.

The new advanced chemistry and physics courses tend to stress the study in greater depth of a smaller number of topics. In order to do so it has been necessary to increase the amount of time given to the subject—either in number of hours per week or in number of semesters devoted to the subject. Descriptive materials have been pruned away to allow more time for study of important topics.

The mathematics of chemistry and physics is being emphasized—both through quantitative students in the subjects themselves and through mathematics programs planned to parallel the science programs.

Science seminars have been a popular method of breaking down subject matter boundaries and of providing for the individual needs of students with varied interests and backgrounds in science. There are almost as many variations as there are seminars. A number of representative ones are described in *New Developments in High School Science Teaching.*

In many places the school program has been expanded by use of out-of-school hours and of non-school personnel and facilities. These administrative innovations include before- and after-school, Saturday, and summer programs; in-service programs for teachers; involvement of college, industry, and government personnel as subject matter specialists; and use of extra-school facilities for teaching purposes.

# Convention Capsules . . . .

K-12 AT K.C.

Local, national, and international personalities will be leaders in forging the future course of science education at NSTA's Eighth National Convention in Kansas City, Missouri, March 29–April 2, 1960.

Variety, similarity, diversity, debate, and compromise—none of these will escape from the spectral dispersion of planned sessions and activities. "Prescriptions"—old and new, tried and tested—will be presented by some of the leading "science education physicians" of our times. The date is set, the operation urgent, and some of the treatments prescribed are briefly given here. These promise to be among the most beneficial ever proffered in NSTA history. See you ON COURSE . . . at KANSAS CITY.

J. STANLEY MARSHALL. Professor of Science Education, The Florida State University, Tallahassee, Florida. Speaker at the Tuesday afternoon General Session of the Association for the Education of Teachers in Science. Subject: "The Science Teacher for American Schools and How He Should Be Educated."

JAMES R. WAILES. Associate Professor of Education, University of Colorado, Boulder, Colorado. Concurrent Panels for In-Service and Pre-Service Education, Panel A, Elementary Level: "In-Service Education for K-12 Science Teachers"; Friday morning.

JAMES W. GEBHART. Montana State University, Missoula, Montana. "Here's How I Do It" Expanding the Curriculum Session, Saturday afternoon. Topic: "The Montana Earthquake."

PHILLIP R. FORDYCE. Oak Park and River Forest High School, Oak Park, Illinois. Member of Panel 8, Concurrent Panels, "Current Curriculum Developments in Biology"; Thursday afternoon.

HELEN W. CRAWLEY. Natick High School, Natick, Massachusetts. "Here's How I Do It" Physical Sciences Session, Saturday afternoon. Topic: "Radioactivity Experiments Using Orange Glazed Ceramics."

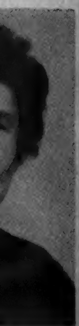
IRVING P. KRICK. Weather Associates, Inc., Denver, Colorado. Speaker, Group I, Current Developments in Selected Science Areas. Topic: "Man's Conquest of the Weather." Friday afternoon.

JAMES WEIGAND. Science Consultant, Office of the Superintendent of Public Instruction, Springfield, Illinois. "Here's How I Do It" Elementary School Science Session. Friday afternoon. Topic: "Eye-Catching Demonstrations."

HUGH ALLEN, JR. Associate Professor of Science Education and Physics, Montclair State College, Upper Montclair, New Jersey; Editor of Convention Proceedings. Presiding, General Meeting for Chairmen and Recorders, Wednesday afternoon.

MATTHEW F. VESSEL. Chairman, Science Education Department, San Jose State College, San Jose, California. Concurrent Panels for In-Service and Pre-Service Education, Panel A, Elementary Level: "Pre-Service Education for K-12 Science Teachers"; Friday morning.

HAROLD L. BODA. Assistant Superintendent, Dayton, Ohio Public Schools. Featured speaker, Supervisors' Luncheon, Tuesday. Topic: "Role of the Supervisor in Developing Values in the Curriculum."



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ROBERT A. BULLINGTON. Department of Biological Sciences, Northern Illinois Universtiy, DeKalb, Illinois. Chairman of NSTA's Science Teaching Materials Review Committee, Dr. Bullington will have four film showings with several films from each area as follows: Wednesday morning, "Science in the Laboratory." Thursday morning, "Biological Science." Friday morning, "Space Exploration." Saturday morning, "Conservation."

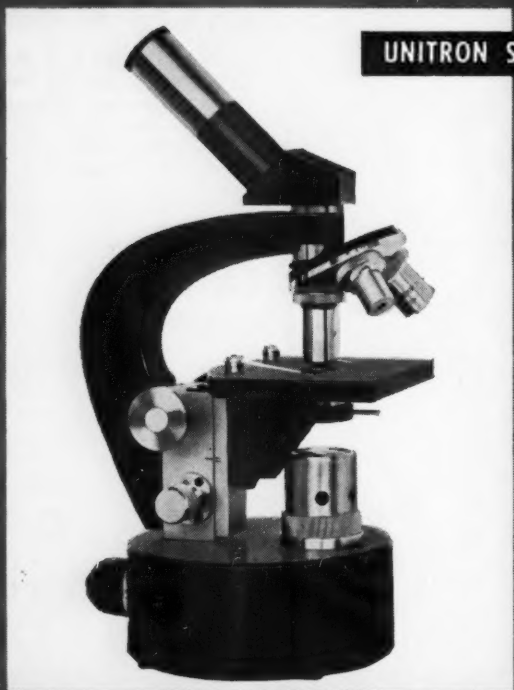
MILDRED T. BALLOU. Elementary Science Teacher, Station KDPS-TV, Des Moines, Iowa Public Schools. Co-chairman of the General Program Committee; Presiding, First General Session, Wednesday afternoon. Subject: "The Ecology of the Educational Community."

GEORGE E. MATHES. Director of Science, Denver, Colorado Public Schools. Presiding at the K-12 Curriculum Center and Consultant Service, Thursday afternoon and Saturday morning.

A. NEAL SHEDD. Specialist for Science Clubs, U. S. Office of Education, Washington, D. C. Supervisors' Section, Round-Table Discussions, Group C: "State Supervisors and Consultants in Science"; Wednesday morning.

KATE BELL. Assistant Director of Elementary Education, Houston Independent School District, Houston, Texas. Concurrent Panels for In-Service and Pre-Service Education. Chairman, Panel B, Intermediate Level: "Pre-Service Education for K-12 Science Teachers." Friday afternoon.

# *UNITRON* student microscopes offer



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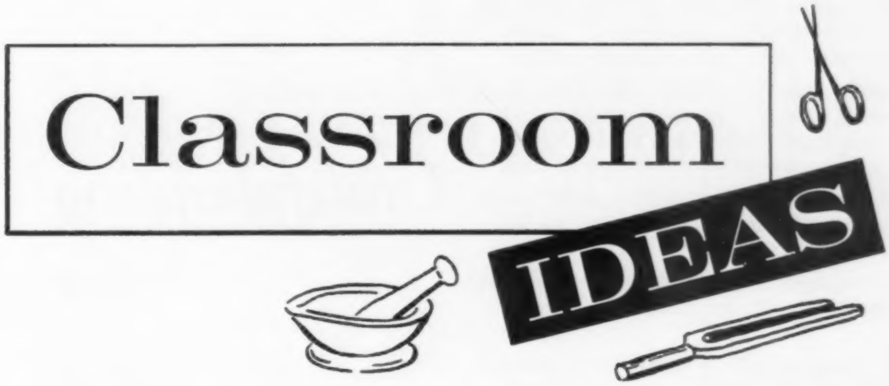
Physics




## Self-Raising Weights on Pulley Systems

By WALTER EISENBERG, Weequahic High School, Newark, New Jersey

The conventional treatment of problems involving pulley systems in high school and college texts seems to leave a serious misunderstanding that appears to be widespread. It is therefore felt important that a word be said to teachers of this subject to prevent future errors in this field.

The textbooks speak of an acting force raising an independent resisting weight; most of them say nothing at all about a force raising its own weight as resistance. Because there is no mention of the latter case, it is often erroneously concluded by the reader that both cases would be worked out the same way. For example, with the single fixed pulley it is shown that it takes a force of more than 150 pounds to raise a weight of 150 pounds, if friction is small. Since nothing is said about a force raising its own weight, it is usually concluded that if a person weighs 150 pounds and tries to raise himself by means of a single fixed pulley, he will have to exert a force of a little more than 150 pounds. In this case, however, the force is just slightly more than 75 pounds. (See Figure 1.)

This comes as a surprise to many students (and some teachers) and is often challenged for proof of correctness. The author has found it a fascinating experiment to allow the challengers to raise themselves on a single fixed pulley system and see by experience that it takes a force of only one-half their weight. The actual experience is worth the effort of setting up the experiment for students.

In offering a theoretical proof for this observation a variety of approaches may be used. It may be shown that if a person raises himself ten feet into the air, twenty feet of rope will have passed through his hands, thus requiring a force of one-half the weight. It may also be shown that as soon as a person takes hold of the free strand, it becomes one of the strands supporting the weight, and the system in effect has become a two-strand pulley system. Other proofs follow along these same lines.

Once the single fixed pulley problem

is clearly understood, it is easy to show the same principle as it applies to the various types of movable pulley systems. When a painter raises himself on a scaffold and four strands support the movable pulley, the so-called free strand he has in his hand is also to be

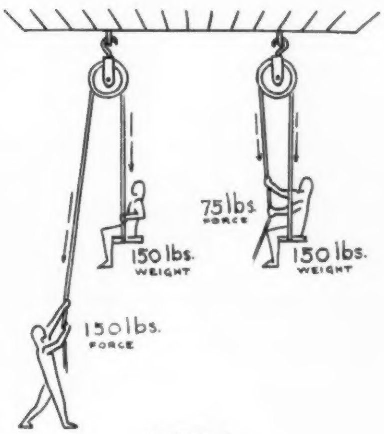



FIGURE 1.

considered as supporting the weight, and the mechanical advantage used in this problem would be five instead of four. The addition of one to the usual mechanical advantage would be applied in all problems of this kind.

Because some textbooks in current use have the wrong answer given in problems of this type, it would be well to check all books and notify each author where such error exists.

## Physics

### Experiment 1 Velocity of Sound in Air by Resonance (Determination of the End Correction)

By JULIUS SUMNER MILLER, El Camino College, El Camino College, California

The usual laboratory method for determining the velocity of sound in air by resonance is well known. A vibrating tuning fork is held over an air column whose length is conveniently varied by changing the height of a water column in it. The theory shows that the first resonant length is approximately one-quarter of the wave length; $L_o = \lambda/4$. This is corrected by adding to $L_o$ six-tenths of the radius of the tube. Then, $V = 4fL$, where L is the

## NSTA CALENDAR

**As a regular feature of *The Science Teacher*, the calendar will list meetings or events of interest to science teachers which are national or regional in scope. Send your dates to *TST's* calendar editor as early as possible.**

**March 29-April 2, 1960:** NSTA Eighth National Convention, Muehlebach and Phillips Hotels, Kansas City, Missouri

**June 29, 1960:** NSTA Annual Summer Meeting with National Education Association, Los Angeles, California; Luncheon meeting and afternoon session

**June 29-July 1, 1960:** Annual Business Meeting of Board of Directors, Los Angeles, California

**September 9-10, 1960:** NSTA Regional Conference, University of North Carolina, Chapel Hill

**October 28-30, 1960:** NSTA Regional Conference, Deauville Hotel, Miami Beach, Florida

corrected length. Finally, $V = V_0 (T/273)^{1/2}$. It is instructive to determine the end correction experimentally. Two methods are available.

*Method* 1. Let $f$ be the fork frequency, $L_0$ the length of the air column, and $d$ the end correction. Then $V = 4f(L_0 + d)$. Use several forks and find the first resonant length for each. Plot $L_0$ against $1/f$. This is a straight line with a y-intercept of magnitude $d$. The slope of the graph is also the velocity of sound.

*Proof:* Write $V/4f = L_0 + d$. This is of the form $y = mx + b$, with intercept $-d$, and slope $V/4$.

*Method* 2. Use two forks an octave apart. C(256) and C′(512) are good. Let C resonate at $L_1$, and C′ at $L_2$. Then

$$4 \times 256 \times (L_1 + d) = 4 \times 512 \times (L_2 + d)$$

Whence $d = L_1 - 2L_2$.

## Experiment 2
## Total Energy of Motion of the Earth

The earth revolves about the sun and rotates on its own axis. For this activity there is an enormous amount of energy used. It is interesting to discover how much energy is involved.

Assume the following data, stated approximately:

Mass of the earth (M) $5.0 \times 10^{27}$ grams ($6 \times 10^{21}$ tons).

Mean radius (r) $6.0 \times 10^{8}$ cm (4000 miles).

Mean distance to the sun (R) $1.5 \times 10^{13}$ cm (93,000,000 miles).

Angular speed of rotation ($\omega$) $2\pi/86{,}400$ rad/sec.

Angular speed of revolution ($\Omega$) $2\pi/365 \times 86{,}400$ rad/sec.

The kinetic energy of rotation is $\frac{1}{2} I \omega^2$. Using the data above we find $KE_R$ to be $2 \times 10^{36}$ ergs. The kinetic energy of translation is $\frac{1}{2} M\Omega^2R^2$. The data gives us for $KE_T$ $2 \times 10^{40}$ ergs.

The translational kinetic energy is therefore about 10,000 times the rotational kinetic energy.

What could this energy do? Converting it to heat energy using $4.2 \times 10^{7}$ ergs/calorie, this could melt over $10^{10}$ cubic miles of ice. Assuming the specific heat of the earth to be about 1/7 calorie/gram/C°, this energy could raise the temperature of the whole earth about 150°.


## Nominees for Board of Directors

As specified in our Constitution, President-Elect Robert A. Rice will become President (NSTA's fifteenth) next July. Candidates for other vacancies to be filled as of June 1 are as follows:

**For President-Elect**

Dr. J. Darrell Barnard; New York University, New York City.

Mrs. Suan Brown; Public School System, Atlanta, Georgia.

**For Secretary**

Mrs. Mildred Ballou; Station KDPS-TV, Public School System, Des Moines, Iowa.

Sr. Mary Charlotte; Sisters of Holy Cross High School, Los Angeles, California.

**For Regional Directors**

**II**

Dr. Hugh Allen, Jr.; Montclair State College, Upper Montclair, New Jersey.

Mr. Richard S. Smith; Haverford Township Senior High School, Havertown, Pennsylvania.

**IV**

Mr. Robert D. Binger; State Department of Education, Tallahassee, Florida.

Mrs. Ruby B. Fitzgerald; Bossier High School, Bossier City, Louisiana.

**VI**

Dr. Clarence H. Boeck; University of Minnesota, Minneapolis, Minnesota.

Dr. Milton O. Pella; University of Wisconsin, Madison, Wisconsin.

**VIII**

Mr. Teruo Masatsugu; State Department of Education, Honolulu, Hawaii.

Dr. Donald W. Stotler; Public School System, Portland, Oregon.

## Proposed Action for K-12 Program

One of the major items in the 1959-60 program of NSTA has been consideration of a K-12 program for science. This has now been reviewed by over 2000 persons in conference situations and by questionnaires. It is expected that another 2000 or more individual teachers will have an opportunity to react and help frame Association policy on this item during the convention in Kansas City, Missouri. The proposed action by the Association has been developed in the form of a tentative resolution by the discussion groups which met in Chicago, Illinois during NSTA's annual meeting with the American Association for the Advancement of Science.

"We believe that NSTA could make a contribution to the further development of K-12 science programs in American schools by taking action as follows:

1. Establish a committee (or utilize an existing committee) to study the K-12 science programs that have been developed or are in the process of development in communities across the country. Careful study of these programs would make available to the NSTA the thinking and planning of hundreds, if not thousands, of teachers and other education workers. We have in mind such programs as are in the process of development in New York City; Fairfax County, Virginia; Cincinnati, Ohio; Lexington, Kentucky; Indianapolis, Indiana; and Glendale, California.

The analysis and study of existing K-12 science programs should take into account at least the following important factors:

a. The different procedures of administrative arrangements characteristic of the programs studied.

b. The different communities represented in the K-12 programs examined—rural, suburban, city.

c. Differences and similarities among the stated goals for the K-12 programs.

d. The policies established or proposed in the various programs for achieving the stated goals; for example, proposed answers to scope and sequence problems and provisions made for taking into account the known individual differences in abilities and interests.

2. During or immediately following the completion of the study indicated above, the committee should explore and formulate tentative goals and policies for developing K-12 science programs looking ahead to realizable achievements over the next ten years.

3. The making of the significant changes in present programs needed to achieve a dynamic K-12 science program in the schools is fundamentally a social process and will require time. Therefore, the tasks suggested above should be prosecuted without delay in order that whatever contribution NSTA may be able to make to the furtherance of the K-12 science program can be initiated within the next two or three years.

4. Finally, we suggest that provisions be worked out for promoting and disseminating the proposals or suggestions developed by the committee through existing and appropriate channels such as the national organizations associated with the principals and the elementary classroom teachers."

## Science for Parents of Elementary School Children

Today every parent is concerned with getting Johnnie to "learn" science. All children *can* learn science. And all parents can help in the process if they are properly informed about three things—science, children, and the learning process.

Early next fall NSTA will publish a booklet for parents, focusing on these three points. Dr. Herbert S. Zim, Educational Director of the Golden Press, Inc., publisher of science books for children, will be the author.

## Convention Flash!

NSTA will be signally honored at the Kansas City convention through the addition of an eminent British scientist who will join with Dr. George B. Kistiakowsky as banquet speaker on Friday evening, April 1. Through cooperation of the British Embassy in Washington and in recognition of the tercentenary of the Royal Society, we will be privileged to hear an address by Professor Samuel Devons, F.R.S., Langworthy Professor of Physics and Director of the Physical Laboratories, University of Manchester. His address will stress the historical perspective of science and will be an appropriate adjunct to that of Dr. Kistiakowsky, who will emphasize the role of science in effective citizenship today.

# FSA Activities

## U. S. Registry—A Progress Report

After many months of planning and collecting statistics of science, mathematics, and language teaching personnel, the 1960 U. S. Registry is now available. As an example of the basic purpose of gathering such a listing, the first mailing to teachers was the National Science Foundation bulletin on summer programs for secondary students of exceptional science and mathematics ability. The blanketing of the United States with announcements of education opportunities for teachers and students provides a program of enrichment available to all those who are capable and interested in participating in various activities.

This is the fifth year of registry mailing service to teachers by the National Science Teachers Association. We have cooperated with the National Council of Teachers of Mathematics, the National Science Foundation, and the Modern Language Association of America in making this year's listing the largest ever undertaken. Over 158,000 names with school addresses of science, mathematics, and modern foreign language teachers have been collected and coded on machine cards to facilitate the mailing of current professional information and materials. During these years, the Registry has been made available to educational, professional, and business-industry groups for a nominal fee. In 1959, over 300 mailings went to groups of teachers in various breakdowns of teaching assignments or geographical areas.

Other information obtained in collect-

**TABLE I**

| STATE | SCIENCE | | | | | | | MATHEMATICS | | | | CATEGORY TOTALS Col. I | Col. II | Col. III | Total of Columns I, II, & III |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | General Science | Biology | Chemistry | Physics | Other | *50% or More | Science Dept. Heads | Grades 7-8 | Grades 9-12 | *50% or More | Math. Dept. Heads | Total Science Only | Total Math. Only | Total Science & Math. Comb. | |
| ALA. | 1,124 | 489 | 343 | 291 | 124 | 745 | 262 | 878 | 911 | 751 | 274 | 1,008 | 1,002 | 643 | 2,653 |
| ALASKA | 31 | 28 | 17 | 16 | 6 | 27 | 4 | 24 | 52 | 24 | 7 | 30 | 44 | 29 | 103 |
| ARIZ. | 168 | 196 | 113 | 93 | 46 | 259 | 70 | 130 | 383 | 285 | 66 | 291 | 357 | 87 | 735 |
| ARK. | 503 | 278 | 173 | 114 | 160 | 379 | 183 | 497 | 560 | 493 | 168 | 513 | 660 | 315 | 1,488 |
| CALIF. | 1,878 | 1,350 | 858 | 657 | 917 | 2,819 | 686 | 2,271 | 4,459 | 3,514 | 682 | 2,825 | 4,750 | 1,430 | 9,005 |
| CANAL ZONE | | | | | | | | | | | | | | | |
| COLO. | 558 | 294 | 204 | 196 | 137 | 502 | 152 | 593 | 698 | 589 | 162 | 601 | 761 | 389 | 1,751 |
| CONN. | 498 | 314 | 237 | 188 | 131 | 630 | 128 | 373 | 790 | 665 | 138 | 717 | 801 | 333 | 1,851 |
| DEL. | 115 | 60 | 49 | 42 | 42 | 117 | 22 | 104 | 144 | 130 | 26 | 143 | 155 | 66 | 364 |
| D. C. | 116 | 71 | 48 | 34 | 34 | 162 | 38 | 196 | 249 | 219 | 47 | 177 | 302 | 87 | 566 |
| FLA. | 1,109 | 580 | 320 | 229 | 295 | 1,128 | 273 | 1,037 | 1,213 | 1,223 | 256 | 1,399 | 1,543 | 545 | 3,487 |
| GA. | 749 | 507 | 339 | 270 | 144 | 761 | 220 | 603 | 1,006 | 832 | 219 | 949 | 1,095 | 480 | 2,524 |
| GUAM | 4 | 1 | 1 | 1 | | 5 | 1 | | 5 | 5 | 1 | 5 | 3 | 2 | 10 |
| HAWAII | 194 | 85 | 51 | 38 | 47 | 179 | 42 | 157 | 247 | 179 | 46 | 223 | 277 | 100 | 600 |
| IDAHO | 202 | 148 | 105 | 91 | 85 | 215 | 62 | 233 | 324 | 277 | 60 | 275 | 349 | 200 | 824 |
| ILL. | 1,772 | 1,258 | 860 | 770 | 347 | 2,111 | 533 | 1,156 | 2,748 | 2,198 | 508 | 2,604 | 2,733 | 1,213 | 6,550 |
| IND. | 847 | 800 | 546 | 500 | 209 | 942 | 281 | 1,001 | 1,498 | 1,231 | 302 | 1,291 | 1,497 | 780 | 3,568 |
| IOWA | 1,066 | 665 | 474 | 506 | 255 | 946 | 346 | 945 | 1,248 | 1,037 | 333 | 1,208 | 1,335 | 769 | 3,312 |
| KANS. | 616 | 509 | 362 | 319 | 123 | 515 | 248 | 458 | 890 | 630 | 242 | 704 | 810 | 485 | 1,999 |
| KY. | 525 | 341 | 220 | 154 | 158 | 464 | 142 | 444 | 691 | 528 | 139 | 639 | 702 | 425 | 1,766 |
| LA. | 922 | 508 | 364 | 187 | 194 | 636 | 219 | 765 | 979 | 817 | 205 | 890 | 1,040 | 719 | 2,649 |
| MAINE | 243 | 193 | 182 | 154 | 82 | 247 | 109 | 122 | 401 | 255 | 102 | 260 | 312 | 226 | 798 |
| MD. | 814 | 372 | 233 | 170 | 140 | 794 | 184 | 763 | 872 | 898 | 181 | 848 | 1,022 | 476 | 2,346 |
| MASS. | 1,331 | 654 | 551 | 473 | 261 | 1,488 | 327 | 1,227 | 1,994 | 1,703 | 327 | 1,527 | 2,094 | 922 | 2,543 |
| MICH. | 1,781 | 1,027 | 748 | 584 | 340 | 1,904 | 471 | 2,094 | 2,401 | 2,113 | 458 | 2,032 | 2,779 | 1,414 | 6,225 |
| MINN. | 1,161 | 647 | 502 | 469 | 202 | 1,242 | 352 | 1,229 | 1,429 | 1,364 | 341 | 1,403 | 1,653 | 671 | 3,727 |
| MISS. | 437 | 273 | 224 | 123 | 153 | 332 | 184 | 440 | 538 | 456 | 202 | 493 | 624 | 277 | 1,394 |
| MO. | 836 | 573 | 383 | 325 | 216 | 719 | 282 | 707 | 1,186 | 868 | 270 | 907 | 1,179 | 581 | 2,667 |
| MONT. | 267 | 160 | 118 | 118 | 82 | 249 | 82 | 216 | 326 | 242 | 81 | 212 | 270 | 268 | 750 |
| NEBR. | 440 | 362 | 242 | 266 | 142 | 398 | 190 | 337 | 616 | 449 | 184 | 516 | 540 | 383 | 1,439 |
| NEV. | 69 | 34 | 21 | 24 | 29 | 55 | 12 | 77 | 88 | 67 | 17 | 63 | 99 | 71 | 233 |
| N. H. | 171 | 128 | 115 | 105 | 50 | 222 | 58 | 119 | 296 | 225 | 55 | 222 | 255 | 137 | 614 |
| N. J. | 1,006 | 662 | 527 | 387 | 225 | 1,436 | 290 | 671 | 1,753 | 1,490 | 284 | 1,634 | 1,800 | 571 | 4,005 |
| N. M. | 249 | 190 | 119 | 82 | 52 | 250 | 75 | 255 | 374 | 328 | 68 | 307 | 410 | 187 | 904 |
| N. Y. | 2,908 | 1,695 | 1,383 | 1,001 | 1,043 | 3,737 | 773 | 2,564 | 4,170 | 3,822 | 721 | 4,287 | 4,848 | 1,393 | 10,528 |
| N. C. | 1,304 | 743 | 502 | 398 | 302 | 887 | 359 | 1,161 | 1,287 | 919 | 306 | 1,085 | 1,402 | 1,061 | 3,548 |
| N. D. | 282 | 210 | 154 | 118 | 95 | 214 | 122 | 282 | 328 | 236 | 119 | 263 | 324 | 265 | 852 |
| OKLA. | 693 | 471 | 275 | 194 | 153 | 564 | 222 | 733 | 856 | 726 | 258 | 692 | 994 | 428 | 2,114 |
| OHIO | 1,911 | 1,151 | 946 | 736 | 616 | 2,152 | 468 | 1,754 | 2,654 | 2,248 | 448 | 2,592 | 2,789 | 1,336 | 6,717 |
| ORE. | 444 | 324 | 200 | 142 | 118 | 483 | 122 | 284 | 705 | 496 | 130 | 556 | 652 | 332 | 1,540 |
| PA. | 2,409 | 1,366 | 1,072 | 861 | 593 | 2,869 | 587 | 2,108 | 3,417 | 2,984 | 558 | 3,569 | 3,809 | 1,197 | 8,575 |
| PUERTO RICO | 97 | 85 | 53 | 52 | 16 | 98 | 27 | 79 | 154 | 97 | 22 | 101 | 106 | 120 | 327 |
| R. I. | 161 | 77 | 56 | 36 | 23 | 164 | 39 | 166 | 236 | 170 | 37 | 171 | 209 | 169 | 549 |
| S. C. | 904 | 352 | 254 | 167 | 86 | 567 | 199 | 705 | 752 | 790 | 186 | 785 | 906 | 501 | 2,192 |
| S. D. | 265 | 182 | 135 | 121 | 66 | 218 | 115 | 214 | 328 | 221 | 91 | 263 | 266 | 267 | 796 |
| TENN. | 632 | 428 | 317 | 211 | 172 | 571 | 207 | 625 | 917 | 731 | 212 | 822 | 1,072 | 419 | 2,313 |
| TEXAS | 1,806 | 1,338 | 886 | 656 | 628 | 1,820 | 598 | 2,126 | 2,900 | 2,469 | 635 | 2,648 | 3,989 | 865 | 7,502 |
| UTAH | 242 | 138 | 74 | 68 | 90 | 258 | 71 | 314 | 340 | 294 | 67 | 262 | 412 | 194 | 868 |
| VT. | 144 | 108 | 90 | 85 | 46 | 154 | 59 | 85 | 222 | 132 | 50 | 156 | 172 | 124 | 452 |
| VA. | 1,075 | 546 | 368 | 221 | 127 | 950 | 229 | 890 | 1,206 | 1,096 | 225 | 1,101 | 1,278 | 566 | 2,945 |
| VIRGIN ISLANDS | | | | | | | | | | | | | | | |
| WASH. | 600 | 433 | 292 | 210 | 151 | 646 | 183 | 882 | 1,069 | 784 | 176 | 711 | 1,239 | 575 | 2,525 |
| W. VA. | 564 | 314 | 216 | 145 | 100 | 450 | 118 | 463 | 592 | 504 | 124 | 703 | 661 | 236 | 1,600 |
| WISC. | 755 | 561 | 420 | 373 | 180 | 902 | 277 | 523 | 1,195 | 926 | 275 | 1,019 | 1,122 | 587 | 2,728 |
| WYO. | 91 | 81 | 64 | 58 | 26 | 95 | 43 | 76 | 163 | 114 | 42 | 112 | 146 | 79 | 337 |
| TOTAL | 39,089 | 24,360 | 17,406 | 13,829 | 9,992 | 40,677 | 11,346 | 36,165 | 54,860 | 45,862 | 11,173 | 48,814 | 59,649 | 25,995 | 134,458 |

* Teachers who spend 50% or more of their time teaching Science or Mathematics.

ing data from principals includes the type of school and community, the sex of the teachers, the school enrollment, and the grade levels of the reporting schools. These data will be compiled, reported, and interpreted by the National Science Foundation. Excellent opportunity for research studies using these statistics or questionnaires sent to controlled samplings will develop as we make the U. S. Registry available to graduate students. (See Table I for statistics on science and mathematics.)

Within the grand total of 158,000 teachers are included 48,814 who teach only science and 25,995 who teach science and mathematics. Those who teach only mathematics number 59,649 and approximately 23,000 modern language teachers are reported. These figures are based on reports made by principals of 19,819 public and private secondary schools. Names are continually being added as forms are received in the headquarters office. Those reporting represent 75 per cent of all the secondary schools in the United States; the question remains as to why the other 25 per cent of the principals have not reported and what improvements can be made to have all teachers represented on the registry.

If readers are interested in or have a need for other tabulations on science, mathematics, or modern language teaching personnel, write to NSTA headquarters asking for registry information.

## Research Participation

We are convinced that many science teachers want to do research while they are teaching. Last fall all NSTA members were alerted that the FSAF budget for the current year contained some funds to support research projects, and that research proposals would be accepted. The response to this announcement was gratifying. Late in January a group of research scientists, science teachers, and science educators met in Washington to evaluate the proposals that had been received. Members of the group were pleased with the quality of these proposals, but it was not possible to award grants to all of the applicants. Those to whom support was granted, together with the titles of their research studies, are as follows:

1. Harold L. Eddleman, Salem-Washington High School, Salem, Indiana.

   **Project:** A Search for Mutations in *Tribolium castaneum*.
2. Cyril S. Kaplan, Flushing High School, New York.

   **Project:** Gravimetric Determination of Complex-Ion Formation in Nitrate Melts.
3. Gerald Mallmann, Fox Valley Lutheran High School, Appleton, Wisconsin.

   **Project:** The Construction of Copper, Cuprous Chloride, Magnesium Batteries.
4. Sister M. Monica Asman, O.S.F., St. Mary's Academy, Winlock, Washington.

   **Project:** The Yellow Fever Transmitting Mosquito, *Aedes aegypti*.
5. Sister M. Stephen McCollum, C.S.J., Luckey High School, Manhattan, Kansas.

   **Project:** General Fallout Patterns of Strontium 90 in the United States in the Early Fall of 1959.
6. George C. Turner, Claremont Senior High School, California.

   **Project:** Professional and Lay Perceptions of Issues Confronting Science Education in the Public Schools.
7. Martin Van Dyke, Denver Christian High School, Colorado.

   **Project:** A Study of the Reaction of Alpha-Benzoin-Phenylhydrazone in Pyridine with Copper Sulfate in Water.
8. Ruth O. Wenner, Lyons Township High School, Western Springs, Illinois.

   **Project:** The Utilization of Certain Amino Acids by Kloeckera Yeasts.

# BOOK Reviews

**Green Universe.** Edward F. Dolan, Jr. 244p. $3.50. Dodd, Mead and Company, 432 Fourth Ave., New York 16, N. Y. 1959.

The story of the last complete scientist, Baron Alexander Von Humboldt, and his travels and studies with his companion Aime Bonpland are related in superb narrative, often with true scientific insight on the part of the author. Major episodes include exploration of the Orinoco, the climb of Mount Chimborazo, and the survey of Russia's natural resources. Alexander friendship with Thomas Jefferson and Simon Bolivar and his snub by Napoleon are treated as if Dolan had been a witness.

Von Humboldt's concern with earth magnetism, vulcanism, and harmony in all nature is carried throughout the story, as is his revulsion against slavery. The book is extremely well written, in warm, flowing style and the reporting factual.

RUBEN PARSON
*Northern Illinois University*
*DeKalb, Illinois*

**Planning and Organizing Science Programs for Elementary Schools.** Martha Glauber Shapp. 72p. $1. The Grolier Society, Inc., 575 Lexington Ave., New York 22, N. Y. 1959.

Many educators are currently developing science programs for the K-6 years. A helpful source of ideas will be found in this teacher's guide to *The Book of Knowledge.* The topics covered are those commonly found in the elementary science curriculum. They are Weather, Living Things Around Us, Our Earth, Beyond Our Earth, Magnetism and Electricity, Transportation, and Communication.

Each subject matter area is organized in a similar fashion. Following the introductory remarks, there is a topical outline of subdivisions of the subject. For each topic, specific references are given to the encyclopedia volumes. There is an indication of the usefulness of the material at the K-3 and 4-6 levels.

The references are followed by a section on "Things to Do" for each major topic. Suggestions include experiments, demonstrations, collections, construction activities, art work, and reference research.

The classroom teacher will find frequent use for this handy guide if the encyclopedia set is available; it serves as reference to resource material for student and teacher. The outlines of subject matter can be used as guides in unit planning. The "Things to Do" should enrich classroom activities for every teacher.

The publishers have performed a unique service in providing teachers with this easy-to-use guide.

ROBERT A. BULLINGTON
*Northern Illinois University*
*DeKalb, Illinois*

**All About Missiles and Satellites.** David Mark. 96p. $1.50. Cowan Publishing Corp., 300 West 43rd St., New York 36, N. Y. 1959.

The author has performed an excellent job of describing and explaining the basic principles of missiles, satellites, and space travel on a level that is designed to reach the high school student.

This paper-bound book is divided into two sections. The first deals with missiles and their airframes propulsion systems, nose cones, and guidance systems. It also includes a directory that describes and illustrates the various missiles used by the armed forces.

The second part considers the launching of satellites, satellite orbits, how satellites are able to telemeter information back to earth, and the technical terms commonly used in missile and satellite work. It concludes with a review of the outstanding facts about space travel, and the reasons why men are beginning to reach more for the stars and outer space.

Recommended for high school students, their teachers, and their parents.

HAROLD S. SPIELMAN
*Associate Professor of Education*
*City College of New York,*
*New York*

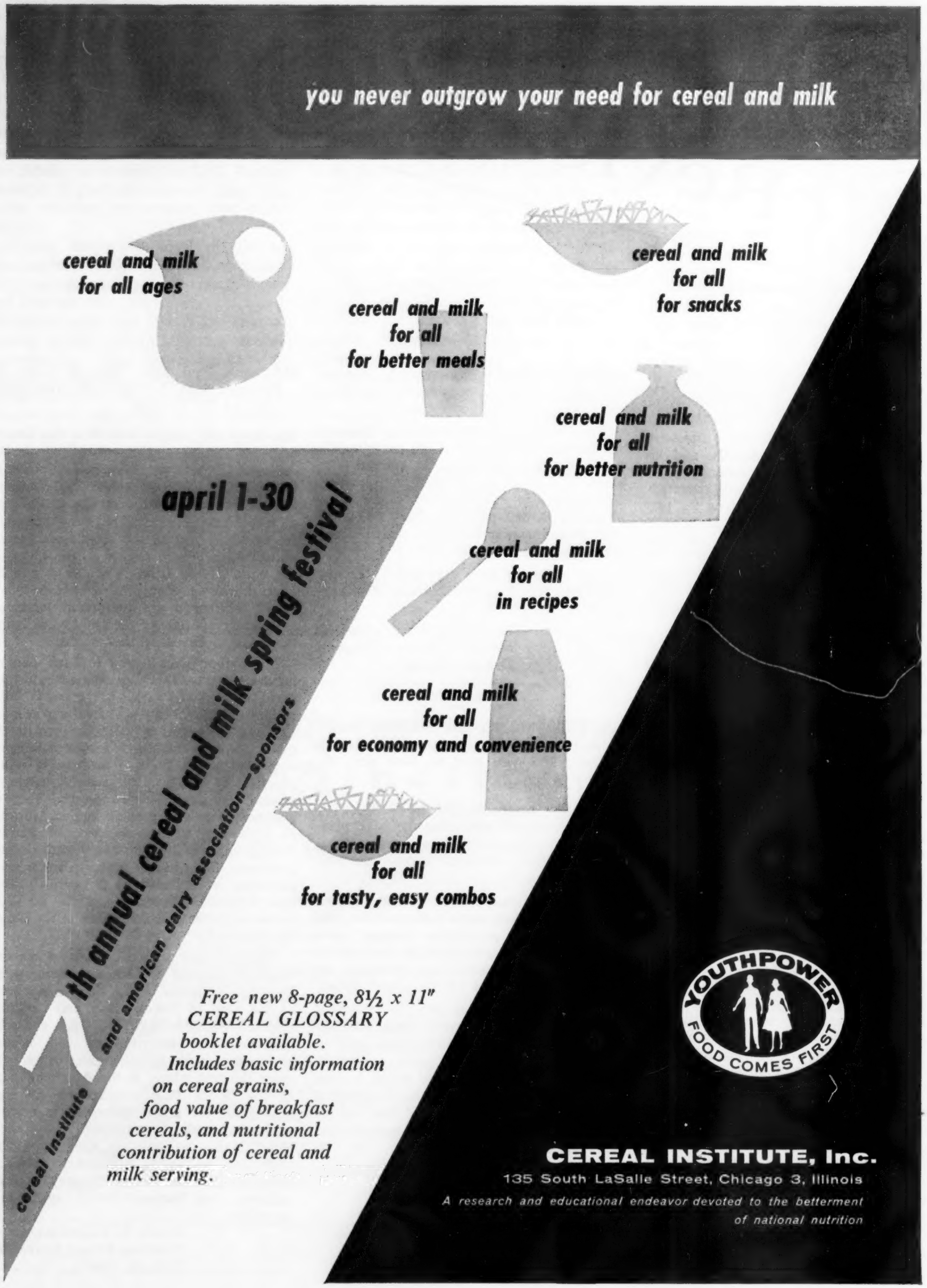
**90° South.** Paul Siple. 384p. $5.75. G. P. Putnam's Sons, 210 Madison Ave., New York 16, N. Y. 1959.

The book *90° South* describes the historical background and the building of the American Base at the South Pole. It presents in simple language the human and material aspects of this special International Geophysical Year project. The narrative style employed to portray the sociological, technological, and basic science drama gives to the book a very strong element of human interest. The simplicity with which everyday events are related and interpreted illustrates the literary aptitude of the author and helps the book to be easily understood.

The author gives reality to basic human behavior patterns in describing the camp personnel with the varied backgrounds, education, and ethical codes. The basic principles in human behavior are exposed and made quantitative by the author in the techniques employed to maintain a continuing work program in the face of material, environmental, and humanistic handicaps. The descriptions are both graphic and measurable in portraying the development of mutual collaboration between military and civilian personnel. Keen insight is shown for human emotions when relations between on-the-spot scientific personnel and the administrative scientific personnel back in the States are analyzed.

The very deep academic devotion to polar research assigned to Admiral Richard E. Byrd by the author of this book is symbolic of the kind of human drive and devotion required in many areas of basic scientific research. The contributions for science which were made by the eighteen men who spent the first winter at the American Base at the South Pole are ranked as high among all the accomplishments in science made during the International Geophysical Year. Many details of a scientific nature pertaining to upper atmosphere physics, meteorology, glaciology, geology, oceanography, and astronomy are specifically described.

LOREN T. CALDWELL
*Northern Illinois University*
*DeKalb, Illinois*


you never outgrow your need for cereal and milk
cereal and milk
for all ages
cereal and milk
for all
for better meals
cereal and milk
for all
for snacks
cereal and milk
for all
for better nutrition
cereal and milk
for all
in recipes
cereal and milk
for all
for economy and convenience
cereal and milk
for all
for tasty, easy combos
april 1-30
7th annual cereal and milk spring festival
cereal institute and american dairy association—sponsors
Free new 8-page, 8½ x 11"
CEREAL GLOSSARY
booklet available.
Includes basic information
on cereal grains,
food value of breakfast
cereals, and nutritional
contribution of cereal and
milk serving.
YOUTHPOWER
FOOD COMES FIRST
CEREAL INSTITUTE, Inc.
135 South LaSalle Street, Chicago 3, Illinois
A research and educational endeavor devoted to the betterment
of national nutrition

# SCIENCE TEACHING MATERIALS

**Prepared by NSTA Teaching Materials Review Committee**
**Dr. Robert A. Bullington, Chairman**
**Northern Illinois University, DeKalb**

## BOOK BRIEFS

**The Fifth Mental Measurements Yearbook.** Oscar Krisen Buros, Editor. 1292p. $22.50. The Gryphon Press, 220 Montgomery St., Highland Park, N. J. 1959.

Critical reviews of tests published since 1952, hence a supplement to the previous Mental Measurements Yearbooks. References to studies and research on the tests are also included, as well as reviews of books in the field of measurement. Reviewers are selected for competency in their fields. An invaluable help in the selection of standardized tests in any field.

**The Mammals of North America.** E. Raymond Hall and Keith R. Kelson. Volumes I and II. 1194 p. $35. The Ronald Press Co., 15 East 26th St., New York 10, N. Y. 1959.

An impressive taxonomic reference work describing over 3800 kinds of mammals from Greenland to Panama and to Alaska. Equipped with artificial keys to help with identification of species, along with many distribution maps, numerous drawings of mammals, and details of skull structure. Quality printing throughout in easy-to-read print with a sturdy binding that should stand much use. A valuable addition to the library of anyone who might be dealing with mammalian taxonomy

**Curious Naturalists.** Niko Tinbergen. 280p. $5. Basic Books, Inc., 59 Fourth Ave., New York 3, N. Y. 1958.

An excellent, illustrated, scholarly introduction to the interpretation of animal behavior. Data collected by the author during 25 years of field investigations are presented in nontechnical terms. Orientation, territory formation and defense, protective coloration, life cycles, interrelationships, and other pertinent topics are discussed. Readily understandable by senior high school students and nonprofessional naturalists.

**The Human Reproductive System.** Third Edition. Thomas H. Knepp. 56p. $1. Wm. C. Brown Company, 135 South Locust St., Dubuque, Iowa. 1959.

A useful text-booklet for high school students on a subject frequently omitted from biology texts. Developed after many years of experience by the author in teaching the subject in the high school. Text and drawings explain the male and female systems, human embryology, pregnancy, birth, and some aspects of heredity. Paper cover with spiral binding.

**Wonders of the Arctic.** Jacquelyn Berrill. 94p. $2.95. Dodd, Mead and Company, 432 Fourth Ave., New York 16, N. Y. 1959.

Beginning with a descriptive account of the physical setting of the arctic, the author proceeds to give an interesting account of some of the forms of life found there. Strong features of the book include the biological

comparisons and geographical relationships. These interpretations will enable the student to gain a keener appreciation of the physical and natural features of this important land area. Illustrated with line drawings. Recommended for elementary and junior high students.

**Our Space Age Jets. Plastic Magic. Snow Surveyor. Mapping the World.** C. B. Colby. 48p each. $2. Coward-McCann, Inc., 210 Madison Ave., New York 16, N. Y. 1959.

One author has written four very interesting and informative books for upper grade children. Profuse photographs illustrate each. New and unusual information is revealed.

*Our Space Age Jets* pictures and describes 23 jet planes, most of recent design. *Plastic Magic* reveals many fascinating kinds and uses of plastics. *Snow Surveyors* is a fascinating account of the little-known work of the men who record the snowfall in our western mountains for the U. S. Department of Agriculture. *Mapping the World* shows how the U. S. Army Corps of Engineers surveys and maps difficult terrain.

**1001 Questions Answered About the Mineral Kingdom.** Richard M. Pearl. 326p. $6. Dodd, Mead and Company, 432 Fourth Ave., New York 16, N. Y. 1959.

The questions and answers in this book are worded for the secondary school student, and are organized by topics under the gen-

eral heading of Mineral Kingdom. Some topics covered in typical chapters are minerals and crystals, igneous rocks, precious metals, base metals, iron and ferroalloy metals, etc. Answers are sufficiently complete to meet most of the needs of students in general education science. Technical terms have been avoided in most cases. Should be a useful reference in any high school science course.

**Exploring Biology: The Science of Living Things.** Fifth Edition. Ella Thea Smith. 732p. $5.20. Harcourt, Brace and Company, Inc., 750 Third Ave., New York 17, N. Y. 1959.

A popular high school text has been completely reorganized, rewritten, and greatly expanded with many new illustrations. It is brought up-to-date with much new material. The user will find that most of his favorite topics are included, although many will consider it unfortunate that the space devoted to organic evolution has been drastically reduced. The clearly written text and many excellent supplementary features make this a book worthy of consideration by the teacher.

**Wonders of the Deep Sea.** Boris Arnov, Jr. and Helen Mather-Smith Mindlin. 96p. $2.95. Dodd, Mead and Company, 432 Fourth Ave., New York 16, N. Y. 1959.

This informative book explains in an easy-to-follow style many questions that young people pose about the oceans. It relates how the oceans began and the important role they play in relationship to currents, tides, winds, and waves. Ocean life is interestingly portrayed as well as man's attempt to explore its depths. Descriptive drawings add to the reader's understanding. One should gain an appreciation of ocean resources which are of increasing importance to mankind. Recommended for upper elementary and junior high students.

**Wildlife Conservation.** Second Edition. Ira. N. Gabrielson. 244p. $5.50. The Macmillan Company, 60 Fifth Ave., New York 11, N. Y. 1959.

A well-known authority speaks from a lifetime of experience in the problems of preserving our wildlife resources. He stresses the relationships of all forms of wildlife to the conservation of soil, water, forests, and grasslands. A chapter is devoted to the effect of changing agricultural practices upon animal populations. The necessity of balance between productive capacity and harvest of game is emphasized throughout. This readable book is a valuable source of information for any student of biological conservation.

**Understanding Chemistry.** Lawrence P. Lessing. 192p. 50¢. The New American Library of World Literature, Inc., 501 Madison Ave., New York 22, N. Y. 1959.

An interesting account of the role chemistry plays in everyday living written in the language of the layman. Begins with theories relating to the origin of the earth, beginnings of scientific thought, and leads up through the development of commonplace substances and synthetic materials. Book concludes with a summary of the status of chemistry today and a forecast of things yet to be discovered. For the better high school student. A Mentor Book, paper cover.

**Science Since 1500: A Short History of Mathematics, Physics, Chemistry, and Biology.** H. T. Pledge. 358p. $1.85. Harper and Brothers, 49 East 33rd St., New York 16, N. Y. 1959.

The original publication of *Science Since 1500* is now twenty years old—having been published at the outset of World War II. This book's coverage of a subject so impossibly vast and complex must necessarily be selective. For instance, theory largely adumbrates application. Spotty treatment of the biological sciences is illustrated by the excellent analysis of nineteenth-century evolution without similarily considering the relationship of cytology, genetics, and systematics to twentieth-century evolution. A book of greater importance to the physical scientist than to the biological scientist.

**All About Archaeology.** Anne Terry White. 148p. $1.95. Random House, Inc., 457 Madison Ave., New York 22, N. Y. 1959.

The fascinating work of the archeologist as a detective of time is vividly portrayed. Methods of operation, dating techniques, and civilizations of the past interestingly described. Ancient Greece, Troy, palace of Minos, pyramids of Egypt, Incas, Aztecs, and

Mayas are among the discoveries treated. Illustrated with black and white drawings. Recommended for elementary and junior high groups.

**Seeing the Earth from Space.** Irving Adler. 160p. $3.50. The John Day Company, Inc., 210 Madison Ave., New York 16, N. Y. 1959.

Gives detailed knowledge of the information discovered thus far in the space programs. Develops the story of space exploration by simply covering the principles of rocketry, the earth satellites, and rocket programs. Two-thirds of book devoted to explanations of the findings about the earth and near space discovered by the space probes. Well written for junior high students and also useful for senior high study of space. Illustrated with photographs and drawings.

**How Old Is the Earth?** Patrick M. Hurley. 160p. 95¢. Anchor Books, Doubleday & Company, Inc., Garden City, N. Y. 1959.

Portrays man's attempt to date the earth and traces the methods of dating. Includes chapters on the earth's structure and beginnings. Well written. Suitable as reference and interest reading for senior high and college students and adults. Illustrated.

**Men, Moss and Reindeer: The Challenge of Lapland.** Erick Berry. 96p. $2.50. Coward-McCann, Inc., 210 Madison Ave., New York 16, N. Y. 1959.

The upper grade reader will enjoy this story of the Lapps and their complete de-

pendence upon their reindeer herds and the moss upon which the animals feed. Rigors of the Arctic winter and the nomadic life of the summer are well told. Has many fine photographs.

**Albert Einstein.** Arthur Beckhard. 126p. $2.50. G. P. Putnam's Sons, 210 Madison Ave., New York 16, N. Y. 1959.

A well-written biography of the life of Einstein suitable as enrichment reading for junior high school students. Explains his life, his interests, and how he developed his theories. Illustrated with sketches.

**The Young Inventors' Guide.** Raymond F. Yates. 104p. $2.50. Harper and Brothers, 49 East 33rd St., New York 16, N. Y. 1959.

A book for the young inventor. Describes inventors, and inventions of the past that have reaped rewards for their creators. Contains suggestions for protecting an invention; how a patent should be obtained; cost of obtaining a patent; and how to market an invention, once a patent has been granted.

**All About Prehistoric Cave Men.** Sam and Beryl Epstein. 138p. $1.95. Random House, Inc., 457 Madison Ave., New York 22, N. Y. 1959.

Discusses life of early men, who they were, and how they lived. Peking Man, Neanderthal Man, and Cro-Magnon are described. Discoveries of both professional and amateur archeologists interestingly portrayed. Illustrated with drawings. Recommended for elementary and junior high groups.

**Making Electricity Work.** John M. Kennedy. 214p. $3.50. Thomas Y. Crowell Company, 432 Fourth Ave., New York 16, N. Y. 1959.

Explains electricity in terms easily understood. Especially suited for junior high students who are interested in the whole field of electricity. Covers circuits, magnetism, motors, and generators. Ideas for things to build and things to do. Illustrated.

**The Chemical Elements.** Helen Miles Davis. (Revisions by Glenn T. Seaborg.) 204p. 50¢. Science Service, Inc., 1719 N St. N. W., Washington 6, D. C., or Ballantine Books, Inc., 101 Fifth Ave., New York 3, N. Y. 1959.

The authoritative and fascinating story of man's discovery of each of the building blocks of the physical universe. Excerpts from the original publication in the discoverer's own words are included. This is the revised edition of a successful book which has had wide usage. It should prove a valuable aid to teachers who wish to add historical flavor to their discussions. A highly readable handbook which should prove useful to student and teacher alike.

**Water—Or Your Life.** Revised Edition. Arthur H. Carhart. 322p. $4.50. J. B. Lippincott Company, East Washington Square, Philadelphia 5, Pa. 1959.

Every student of conservation should have access to this hard-hitting and authoritative discussion of our national water problems. The well-qualified author stresses the importance of this natural resource and reveals the difficulties, arising from many conflicting interests, of controlling its use. Little changed from the 1951 edition except for a new closing chapter telling of the great strides in water use and pollution control made in the last decade.

**Men, Planets, and Stars.** Clyde B. Clason. 160p. $2.95. G. P. Putnam's Sons, 210 Madison Ave., New York 16, N. Y. 1959.

Brief survey of the developments in astronomy from the time of the Babylonians to the present. Presents an accurate description of our system. Famous astronomers are cited in the presentation of the material. An introduction is given to the field of discoveries in spatial relationships. For junior high school.

**Exploring Physics.** New Edition. Richard F. Brinckerhoff, Judson B. Cross, and Arthur Lazarus. 732p. $5.20. Harcourt, Brace and Company, Inc., 750 Third Ave., New York 17, N. Y. 1959.

The outstanding characteristics of this high school text are: (1) its more than usual comprehensive preview of the year's work in the first two chapters, (2) its use of excellent two-color diagrams, (3) its inclusion of stimulating material for the better students, suggestive of the possibilities of further reading from other sources, and (4) the comprehensive material at the end of the book, including formulas, a mathe-

matics course in outline for those with inadequate background, tables of physical and mathematical constants, and samples of questions from the advanced placement examination in physics. This text is comprehensive and accurate. Physical concepts are carefully explained in a correct manner. Contains a brief explanation of the atomic basis for understanding chemical changes, which is not usually included in a physics course.

**Satellites and Space Probes.** Erik Bergaust. 48p. $2.50. G. P. Putnam's Sons, 210 Madison Ave., New York 16, N. Y. 1959.

Describes the satellite and space programs of the world. Up-to-date pictures and data. Contains information on the present and future programs of the United States and Russia. Excellent photographs and explanatory drawings. Suitable for upper elementary and junior high reading.

**Everyday Life in Prehistoric Times.** Marjorie and C. H. B. Quennell. 226p. $3.50. G. P. Putnam's Sons, 210 Madison Ave., New York 16, N. Y. 1959.

An excellent portrayal of prehistoric man's way of life, based upon archeological findings. Traces man's development of early culture through tools, clothing, and shelter. Covers early man from *Pithecanthropus* to the Celts of England. Interestingly written. Well illustrated with photographs and drawings. Suitable for junior-senior high students and for general reading.



## PROFESSIONAL READING

**"Teaching Machines."** By Jesse H. Day. *Journal of Chemical Education,* 36:591. December 1959. Teaching machines require the active participation of the learner at all times. In this way they differ from other teaching devices. Examples are given of how the machine can be used with a complete description of what a teaching machine is and some of its misuses.

**"Teaching Techniques in the Undergraduate Organic Laboratory."** By S. J. Storfer and E. I. Becker. *Journal of Chemical Education,* 36:614. December 1959. The substitution of the "discovery" technique for "cookbook" methods in the organic laboratory is discussed.

**"Evaluation of High School Physics Courses by College Students."** By Haym Kruglak. *American Journal of Physics,* 27:630. December 1959. College physics students were asked to complete a questionnaire about their high school physics course. The study was done to identify outstanding physics teachers and their methods. Interesting topics, such as the value of the physics course for college preparation, are also discussed.

**"The Prehistory of the Periodic System of the Elements."** By Jan. W. con Spronsen. *Journal of Chemical Education,* 36:565. November 1959. Teachers of chemistry will find that much historical information in this article will enrich a discussion of the history and formulation of the periodic system of the elements. Describes scientists (and their activities) responsible for developing the foundations for the periodic law in an interesting and concise manner.

**"The Flow of Matter."** By Marcus Reiner. *Scientific American,* 201:122, December 1959. Solids, as well as liquids and gases, flow. In some respects, gases behave like solids. This article explains these two paradoxes.

**"The Invention of the Electric Light."** By Matthew Josephson. *The Scientific American,* 201:98. November 1959. Edison's electric light was ". . . an idea not a thing." Explains the economic, technological, and sociological changes that this invention caused. The historic diagrams and schematic circuits will be very interesting to science historians.

**"Ninth Grade Biology—Pros and Cons."** By William W. Sharken. *School Science and Mathematics,* 59:718. December 1959. Discussions of arguments for and against moving biology into the ninth grade, and of the few which are backed up by evidence. Research studies are stressed to throw more light on the problem.

**"Methods of Presenting a One Year Integrated Science Course."** By F. C. MacKnight. *School Science and Mathematics,* 59:730. December 1959. Presentation to show science as a whole, rather than to emphasize the identity of its divisions. Several approaches are: (1) a sequence of merging topics, (2) a chronological one, (3) a geological one, (4) a philosophy of science approach, (5) a case

method approach, or (6) a combination of 1-5.

**"High School Students Evaluate Sectioning."** By H. J. Klausmeier, John Mulhern, and Howard Wakefield. *Educational Leadership*, 17:221, January 1960. The results of the study described were in favor of ability grouping. Indicates that students of low ability were getting less out of school in terms of their social and academic needs than other students.

## AUDIO-VISUAL AIDS

**Solutions.** 16 min. **Ionization.** 18½ min. **Nitric Acid Compounds and the Nitrogen Cycle.** 18½ min. These three films are part of the set of 18 in the new Coronet Chemistry Film Set which covers the topics usually included in high school chemistry. Each film treats the principles related to the topic and presents demonstrations and laboratory experiments. Filmed with cooperation of Wheaton College. Available as a set or singly, in color or black and white. Price (available on request) depends upon length. 1959. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

**Aristotle and the Scientific Method.** A valuable addition to the available films on the scientific method. Dramatization presents a chronological story of the development of ideas concerning the nature of the universe. The story culminates in the observations of Aristotle and his contributions to the scientific method. For senior high science, expecially biology. 13½ min. Color $137.50, B&W $75. 1959. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

**Isaac Newton.** Filmed in England in locales associated with Newton. Good for historical interest, general information on achievements of Newton, and inspiration. Recommended for secondary mathematics and physics. 13½ min. Color $137.50, B&W $75. 1959. Coronet Instructional Films, Coronet Buildings, Chicago 1, Ill.

**Galileo.** A brief story of the major achievements of the great scientist portrayed by actors in settings in Italy. Shows how some of his contributions to science came about, and stresses his problems in fighting tradition. A stimulating film for junior and senior high students of general science and physics. 13½ min. Color $110, B&W $60. 1959. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

**What's Inside the Earth.** A generalized examination of the sedimentary rocks of the crust, inferred composition of the earth's mantle, and determination of the structure of the central core from seismic data. Equipment used for this investigation is shown in operation, giving the student an opportunity to see earth dynamics in action. Produced for use in earth science studies at the elementary and junior high schools. 13 min. Color $135, B&W $70. 1959. Film Associates of California, 11014 Santa Monica Blvd., Los Angeles 25, Calif.

## APPARATUS & EQUIPMENT

**Project-O-Stand.** A unique device that will enable the teacher to assemble his own microprojector by adding 300- or 500-watt, 35-mm slide projector and monocular compound microscope. The image is projected upon a ground glass screen with a magnification about twice that observed in the microscope. For use on demonstration table in front of class. Folds into compact size for storage. No. CI-1, $49. 1960. Central Custom Instrument Company, 539 Lincoln St., Algonquin, Ill.

**Laminated Anatomy Study Cards.** These cards should be a great help to the student of anatomy. They are clear, exact, and complete. Each card has a legend associated with numbers on the drawings. Most practical for the college student but also useful in high school biology. Cards should be of value in connection with dissection. Set 1: *Bones, Muscles and Muscle Insertions*, 21 cards. $2.50. 1956. Set 2: *Arteries, Veins, Nerves*

*and Lymphatics,* 21 cards. $2.95. 1958. Set 3: *Cat, Necturus, Frog and Shark,* 21 cards. $2.50. 1959. Student Merchandise, Inc., 350 Fifth Ave., New York 1, N. Y.

**Bausch & Lomb Student Microscope,** Model ST-22. A new model to replace the former model FL. The ST-22 has improved optical and mechanical features. The general appearance is very similar to that of the older model. $125 each (1-4); $112.50 (5 or more). Bausch & Lomb Optical Company, Rochester 2, N. Y.

**Bausch & Lomb Stereozoom Microscopes,** Model BVB-73 and SVB-73. Sturdily constructed microscopes with the interchangeable "power pod" feature which allows any of the optical units to fit any of the stands. The two models differ only in the stands. BVB-73 has an ordinary rack and pinion stand with a stage and a substage base; SVB-73 has the rack and pinion mounted on a boom extending from a vertical post and heavy base. Either stand seems to work very well for the routine work. The Stereozoom feature works well and is clearly a major improvement in microscope design and construction, particularly in that it eliminates the chance of "losing" the specimen while changing magnification. Model BVB-73, $385 each (1-4); $346.50 (5 or more). Model SVB-73, $414.50 each (1-4); $373.05 (5 or more). Bausch & Lomb Optical Company, Rochester 2, N. Y.



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